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ERRATA.

Page 100, line 9 from foot, for *R.* read *P.*
166, line 3, for *Calanthe* read *Bletia.*
197, line 10 from bottom, *for* Boletin *read* Boletim.
197, line 3 from bottom, p. 198, line 14, and p. 200, lines 7 and 15, *for* ORESTIA *read* ORESTIAS.
198, line 21. *for* Mollec *read* Moller.
309, line 9, for *Godefroyæ* read *Godefroyi.*
364, line 25, for *Achillæa* read *Achillea.*
365, line 3, make the same correction.
384, last line, *for* stimulus shock *read* strong stimulus.
438, line 5, *for* GILEADENSE *read* GILEADENSIS.
459, line 21, after *Nuphar*, for *lutea* read *luteum*.

THE JOURNAL

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THE LINNEAN SOCIETY.

The Effect of Stimulation on Turgescent Vegetable Tissues.

By **Anna Bateson**, Newnham College, Cambridge, and **Francis Darwin**, F.R.S., F.L.S.

[Read 20th January, 1887.]

If the turgescent pith of a growing shoot is freed from the external tissues, it exhibits a sudden increase in length. It also exhibits, as is well known, a subsequent increase in length if placed in damp air or in water. The latter phenomenon, viz. the increase in length when turgescent pith is placed in water, forms the subject of the present paper—a subject which, so far as we know, has not been systematically worked out. The chief point to which we desire to draw attention is the possibility of accelerating and retarding the rate of increase in length by various reagents. We think that this subject is of considerable interest, as bearing on some of the problems of growth. In the pith we have the essential factor in the act of elongation of a growing internode freed from restraint, so that the facts gained by the study of the pith may guide us in the study of normal growth. We by no means assume that our conclusions drawn from the pith-experiments are directly applicable to normal growth, but merely that they throw light in an interesting manner on that subject.

METHOD.

The plants used were the Jerusalem Artichoke (*Helianthus tuberosus*) and the Sunflower (*H. annuus*).

Both of these grew close at hand in the Laboratory garden, and could therefore be used in a perfectly fresh condition. The internodes were freed from the external tissue, so that pieces of pith 12 to 17 centim. in length and about 5 to 10 millim. in thickness were obtained. It is essential that the vascular bundles should be, as far as possible, removed; unless this is carefully done, the specimen, when placed in water, bends, owing to unequal elongation, and is useless for experimental purposes.

The increase in length was measured by means of an auxanometer-lever. One end of the pith was attached to the bottom of a narrow glass jar, the upper end being connected, by means of a thread of plaited silk, with the short arm of the lever.

The form of lever used is a convenient one for growth-experiments. It is made of light wood, 628 millim. in length, and turns on a knife-edge. The thread connected with the plant is also attached to the short arm of the lever by means of a knife-edge-suspension, in the same way as the scale-pans are attached to the beam of a balance. Great freedom is thus ensured in the movement of the lever, a condition not easy to ensure in all forms of auxanometer.

It will be seen that a theoretical error is introduced by the use of a lever in place of a pulley; but when the short arm is of reasonable length, 45 millim., and especially when the thread connecting it with the plant is fairly long in our experiments (38 centim.), the error introduced by the end of the short arm describing an arc instead of a vertical line is so small as to disappear in comparison with other unavoidable errors.

If a strip of pith is fitted up as here described, and the jar is then filled with water, the elongation as exhibited by the descent of the long arm of the lever is most striking; indeed, so rapid is its movement, that it travels in many cases over 10 millim. in one minute. This rapid movement necessitates an occasional alteration in the position of the support on which the lever turns. When the long end of the lever has descended from an angle of 30° or so above the horizon to a corresponding angle below it, the support on which the knife-edge of the lever turns has to be raised so as to bring the long end of the lever once more above the horizon. This disturbance was not found in practice to interfere with the "growth"* of the pith.

The long arm of the lever ends in a needle-point, so that the rate of its descent could be read off on a vertical scale divided in millimeters.

It was found that the best way of estimating variations in the rate of "growth" was to record the times which the end of the lever occupied in travelling over a fixed vertical distance. A space of 1, 2, or 5 millim. was taken, and the movement of the needle-point was timed by means of a stop-watch. By taking the reciprocals of the stop-watch readings, a series of figures proportional to the rate of increase of the pith at short intervals of time was obtained. And if the reciprocals are multiplied by 1000, a convenient series of whole numbers are obtained, such as we give in our Tables. Where the rate of growth, or more briefly the "rate," is put down as 100, it means that the pith was increasing in length at the rate of about half a millimeter (0·46 millim.) per minute. *Thus the unit of rate employed in our Tables is* 0·0046 *millim. of actual increase per minute.*

EXPERIMENTS.

Before we describe the behaviour of the pith to reagents, we must consider its normal behaviour when placed in water. To give a general idea of the amount of increase in length which takes place in a short time, the following measurements are given:—

Aug. 13, 1886.—Sunflower-pith increased in 1 hour 7 minutes at a temperature 17° C. from 192 millim. to 215 millim.

Increase =23 millim., or 11·9 per cent.

Aug. 13, 1886.—Jerusalem-Artichoke pith increased in 1 hour 43 minutes at 16° C. from 215 millim. to 250 millim.

Increase=35 millim., or 16·2 per cent.

Apparent Grand Period.

If the increase in length in water is studied by means of the auxanometer, it is found that the rate is at first slow, but gradually increases, and ultimately diminishes again, thus simulating the Grand Period of Growth. We do not pretend that this phenomenon has necessarily any connection whatever with the grand period of normal growth, since we are aware that purely mechanical changes, such as the untwisting of a *Stipa*-awn in water, exhibit a similar series of rates. But the fact is undoubtedly worthy of record, and possibly of further investigation.

---

* For the sake of brevity, we shall use the term "growth" to mean the increase in length of the pith.

Exp. 1.—Aug. 14, 1886. Sunflower-pith and auxanometer-lever. The cylinder was filled with water at 10.10 A.M.

Times of observation. A.M.	Rate of "growth."
10.12	80
	89
10.13	100
10.13·2	111
10.13·5	117
10.14	133
10.14·2	138
10.14·5	**153**
10.15	151
	151
	151
10.16	142
10.16·2	149
	133
10.17·1	133
10.18	123
10.18·5	117
10.24	85
	74
10.29	60

Exp. 2.—Aug. 3, 1886. Jerusalem Artichoke; lever.

Times of observation. P.M.	Rate of "growth."
5.2	Water.
	107
	192
	222
	256
	285
5.6	**285**
	277
5.6	270
	263
	250
	250
	243
5.9	222
	222

Whatever may be the significance of the "apparent grand period," it was of importance for our work that its existence should be known, since it is obvious that we could not draw any conclusions as to the action of reagents till the normal course of things was known.

EFFECT OF WARMTH.

The results of warming the water in which the pith is placed are of considerable interest, as showing that, although the increase in length of pith, freed from the surrounding tissues and placed in water, must necessarily be abnormal in character, yet that it behaves in a normal manner in response to variations in the temperature of its surroundings; that is to say, "growth" increases with increased temperature, reaches a maximum, and then diminishes.

The method employed was simple. Hot water was allowed to run in at the bottom of the cylinder containing the pith, the overflow being regulated by means of a siphon. The hot water rises to the top, and as the overflow-siphon dipped to the bottom of the cylinder, there was a fairly good mixture of hot and cold water. Nevertheless the temperature was not quite uniform throughout, the upper part being about 0°·5 C. higher than the lower.

Exp. 3.—Aug. 18, 1886. Sunflower-pith; lever.

Times of observation.	Rate of "growth."	Temperature.
P.M.		° C.
12.20	....	16
12.25	142	"
	138	"
	114	"
12.25·5	Hot water turned on.	
12.26·5	86	18
	82	19·2
	85	20·5
	101	22
	101	24·5
12.30	126	26
	153	"
12.31	161	28·5
	181	"
	250	29·5
12.33	344	35·5
	357	"
	333	38·5
	333	"
12.34·5	344	41·5
	400	43
	322	"
	333	"
12.36	333	"
	285	45
	322	48
	312	"
12.37·5	303	50·5
	250	"
12.40·5	285	52
	243	54
	238	"
12.42·2	238	55
	204	56
	192	"
12.45·5	28	56·2
12.46	Stopped.	56·5

Exp. 4.—Aug. 18, 1886. Sunflower-pith ; lever.

Times of observation. P.M.	Rate of "growth."	Temperature. ° C.
3.8	Water put in.	15
3.10	78	,,
	83	,,
	75	,,
3.12	65	,,
3.13·5	Hot water in.	
	56	18·5
3.16	81	20·7
3.16·7	85	23·5
3.17·5	112	25
3.18·5	140	28
	222	,,
	222	29·6
3.20	250	31·5
3.21·5	370	36·5
	384	,,
	370	,,
3.22·2	400	38·5
	400	,,
	434	,,
3.23	400	40·5
	400	,,
	333	42
3.24	370	44
	312	,,
	370	,,

Times of observation. P.M.	Rate of "growth."	Temperature. ° C.
3.25	285	46
	370	,,
	370	,,
	312	47·7
3.27	333	48·7
	400	,,
	434	,,
	344	,,
	370	,,
	285	,,
	312	52
	370	,,
	333	,,
	333	52·5
	333	,,
	312	,,
	285	,,
3.30	285	53·5
3.31	250	,,
	285	,,
	270	54·5
	200	55·5
3.34	71	56·5
3.38	Stopped.	57·5
3.40	Shortened. −117 (contraction 1 mm.) Flaccid.	

Exp. 5.—Aug. 19, 1886. Sunflower-pith.

Times of observation. A.M.	Rate of "growth."	Temperature. ° C.
10.40	Water put in.	17
	85	,,
	85	,,
10.44	84	,,
10.45	80	,,
	Hot water put in.	
10.46·5	83	20·5
	100	22
	111	24
10.48·5	120	26
10.49	166	29·5
	158	30·5
	212	32
10.50·5	238	33
	270	34·5
	285	,,
	312	,,
10.52	312	36·5
	333	,,
10.52·9	322	38·5
	312	,,
	344	,,
10.54	285	41·5
10.56	169	41·5
10.56·5	192	44
	222	,,
	200	46·5
10.58	181	47
	181	48·5
10.59	188	48·7
	222	,,
11.0·0	200	50·7
	200	51·5
	204	,,
11.1·5	192	52·5
11.2·5	142	54
	100	54·7
11·4	35	57
11.4·5	Began to shorten.	57·5
11.5·5	−62 (contracts 2 mm.)	

The connection between changes of temperature and changes in the rate of growth are shown in the accompanying curves. The irregularity in the rate of growth shown in our Tables is here rendered perceptible.

The first point that strikes one on looking at the results is the high temperature at which growth can go on. The following are the maximum temperatures of five experiments :—

56°·5 C.	57°·5 C.
54°·5	57°·5
52°·5	

These maxima are certainly high when we compare them with the maxima recorded for normal growth. For the Maize, Pfeffer gives 46°·2 C. as the highest temperature at which growth occurs; but 56°–57° C. is not a higher temperature than plants are known to be capable of surviving*.

Fig. 1.

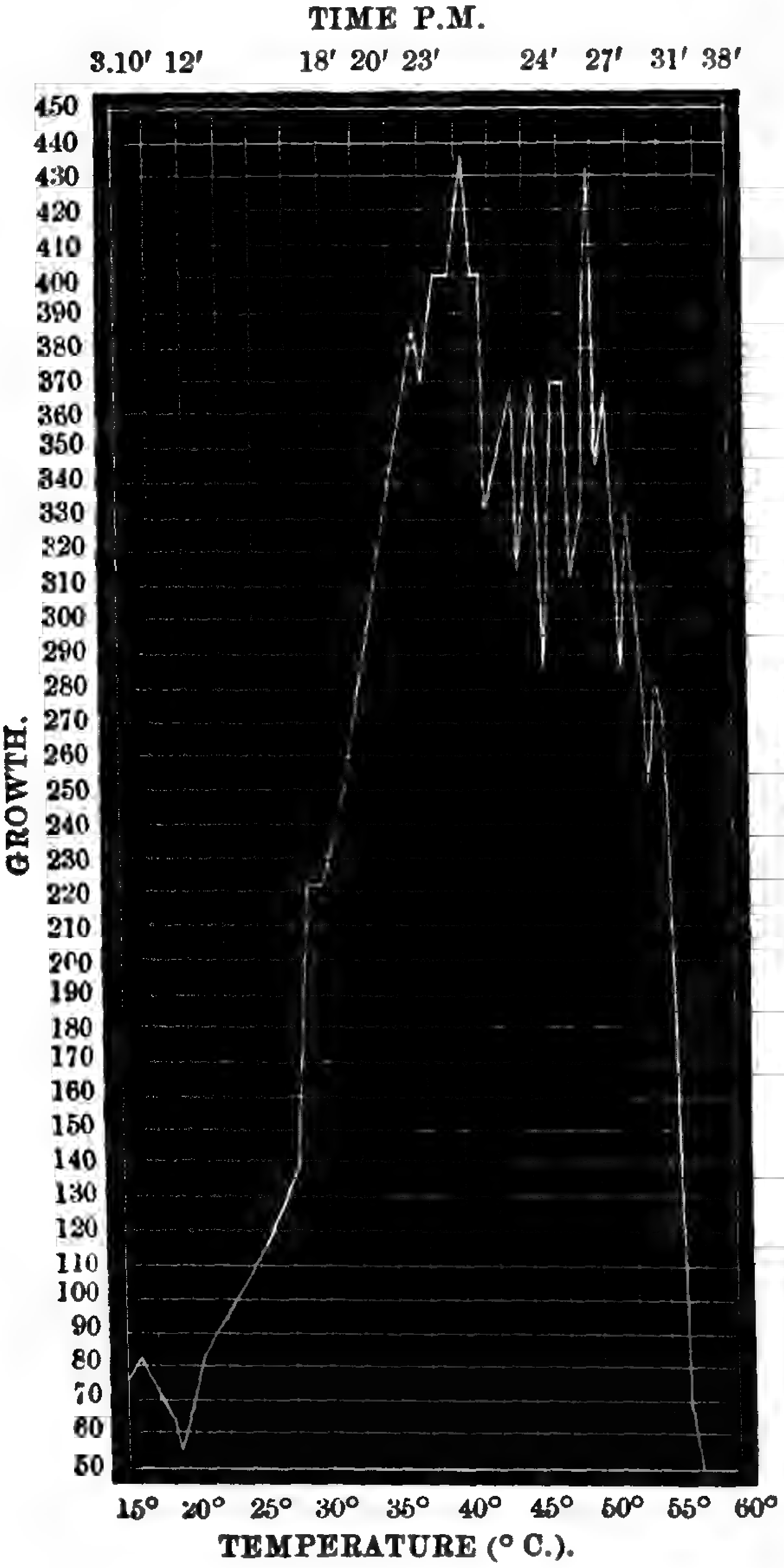
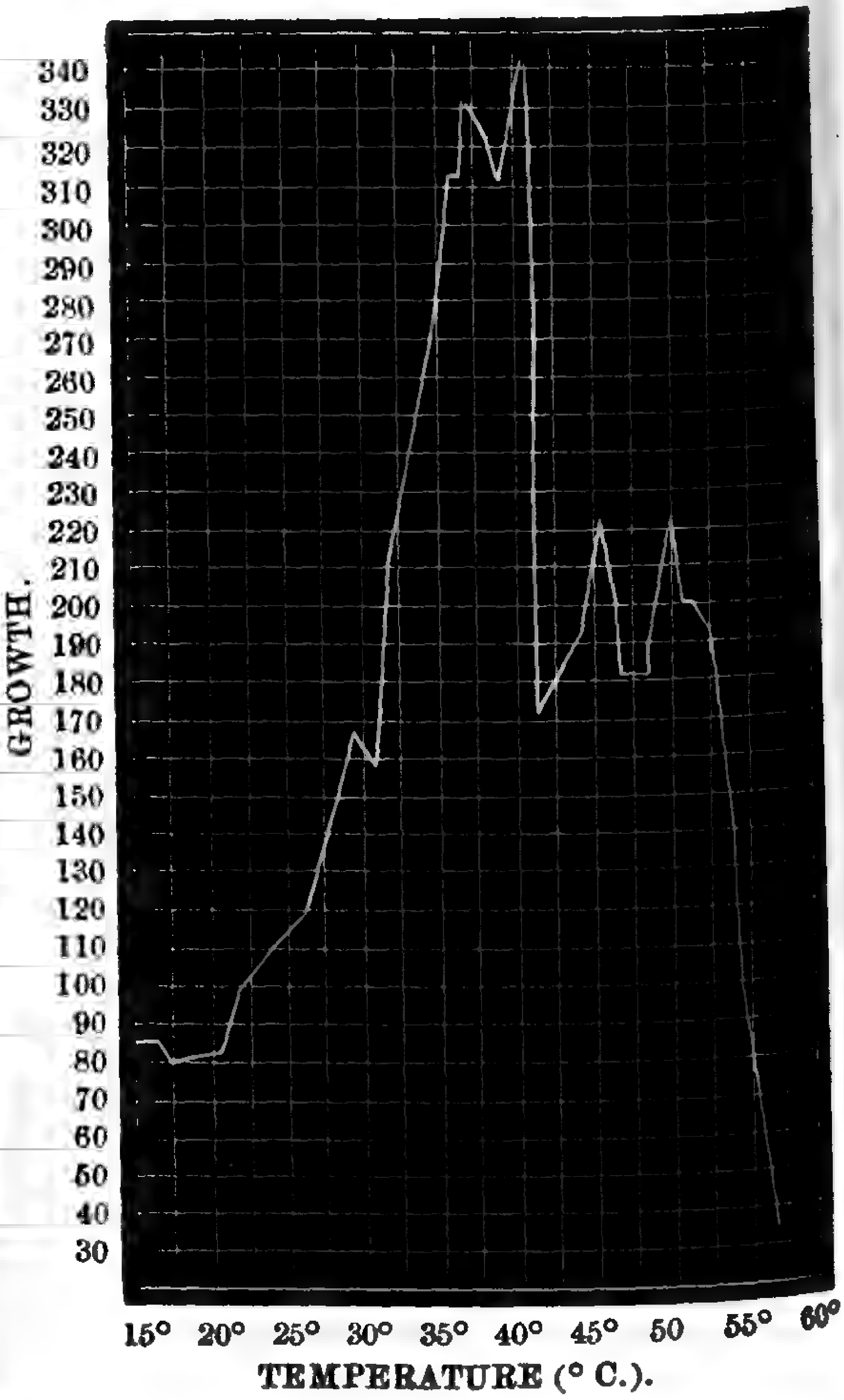


Fig. 2.



Diagrams showing effects of Rise of Temperature.

Pfeffer † has pointed out that where the maximum is a very high temperature, it often happens that the maximum growth takes place at a temperature only slightly lower than the temperature which causes death. This seems to be sometimes the case in our experiments: the rate of "growth" increases until suddenly it becomes much slower and stops altogether. In other cases the "growth" begins to get slower at a temperature considerably below the fatal temperature. But in these cases also there is a sudden fall in the rate of "growth" just before death occurs.

---

* Wiesner, Sitzungsb. der Wiener Akad. 1871, Bd. lxiv., got seeds of *Pinus Laricio* which had been exposed for 15 minutes to temperatures of 55°, 60°, and 70° C., to germinate; and seeds of *Abies excelsa* exposed to a temperature of 70° C. for the same time germinated.

† 'Pflanzenphysiologie,' ii. p. 123.

Effect of Reagents.

1. *Stimulating Effect of Alcohol.*

The pith was fitted up in a cylinder of water and, as soon as a few readings had been taken, the spirit was added in such a way that it mixed quickly with the water. It has been shown that after a short immersion in water, growth begins to slow down, so that any acceleration in the rate can be very clearly seen.

Exp. 6.—Aug. 25, 1886. Sunflower-pith.

Times of observation.	Rate of "growth."	Temperature.
P.M.		° C.
3.30	Water put in.	20·5
3.32·5	83	"
	81	"
	71	"
	72	"
	75	"
3.42	72	"
	Siphoned out water, 2 per cent. spirit in.	20
3.44	108	"
3.45	99	"
	93	"
3.46	75	"

Result with methylated spirit 2 per cent.: acceleration 100:150.

Exp. 7.—Sept. 7, 1886. Jerusalem-Artichoke pith; lever.

Times of observation.	Rate of "growth."	Temperature.
P.M.		° C.
12.11	Tap-water put in.	19·5
12.15	344	"
	285	"
12.15·5	256	"
	250	"
12.17	222	"
	238	"
12.17·5	222	"
12.18	200	"
12.20	149	"
12.20·2	142	"

Exp. 7 (continued).

Times of observation.	Rate of "growth."	Temperature. ° C.
P.M.		
12.20·5	Siphoned out water.	
12.21·5	4 per cent. spirit in.	17·5
12.22	256	,,
12.22·5	196	,,
	200	,,
12.23	153	,,
12.23·5	138	,,
12.23·9	133	,,
12.24	125	,,
12.25·5	105	,,

Result with 4 per cent. methylated spirit: acceleration 100 : 180.

Exp. 8.—Sept. 7, 1886. Jerusalem-Artichoke pith.

Times of observation.	Rate of "growth."	Temperature. ° C.
P.M.		
3.50	Tap-water (370 c. c.).	19
3.52·5	204	,,
	196	,,
3.53	166	,,
	129	,,
	108	,,
3.55·5	100	,,
3.56·5	89	,,
3.58	89	,,
3.58	4·3 per cent. spirit.	20
	333	,,
3.59	285	,,
	250	,,
3.59·2	200	,,
4.0	200	,,
4.1	166	,,
4.1·5	144	,,
4.2·2	138	,,

Result with 4·3 per cent.: acceleration 100 : 375.

It will be seen that in these three cases the acceleration is only temporary, the rate begins to fall after a sudden rise.

A number of experiments were made on the effects of alcohol, the results of which agree with those already given; that is to say, a temporary and variable amount of acceleration is produced. The temperature of the water was not noted in all cases; but we satisfied ourselves that the acceleration is not to be accounted for by the slight rise in temperature which follows the mixture of the spirit and water. Experiment 7 shows clearly that a great acceleration occurs, even when the temperature is made to *diminish*, on the addition of alcohol.

The following experiments give some notion of the percentage of alcohol necessary to produce acceleration. In these cases absolute alcohol was used instead of methylated spirit.

Acceleration produced by—

2 per cent.... 100 : 122
2 „ ... 100 : 105
1·5 „ ... 100 : 108
1·5 „ ... 100 : 172

No effect produced by—

1·5 per cent.
1 „
1 „
0·5 „

We may conclude that 1·5 per cent. of absolute alcohol is about the critical point; while strengths greater than this can be trusted to produce acceleration, those lower can be trusted to produce no effect. The fact that alcohol produces a sudden acceleration in rate of increase may be simply shown by a different method. If a Dandelion flower-stalk is split, each half curls up into a helix. If now a slight weight is attached to one end of the helix, it may be made to hang in a vessel of water, when the weighted end will revolve with more or less rapidity. If an index is fixed to the weighted end of the spiral, and a graduated scale applied round the vessel, any diminution or increase in the rate of revolution can be easily measured. With such an apparatus we have repeatedly observed a marked increase in the rate of revolution when alcohol is added.

Fig. 3.

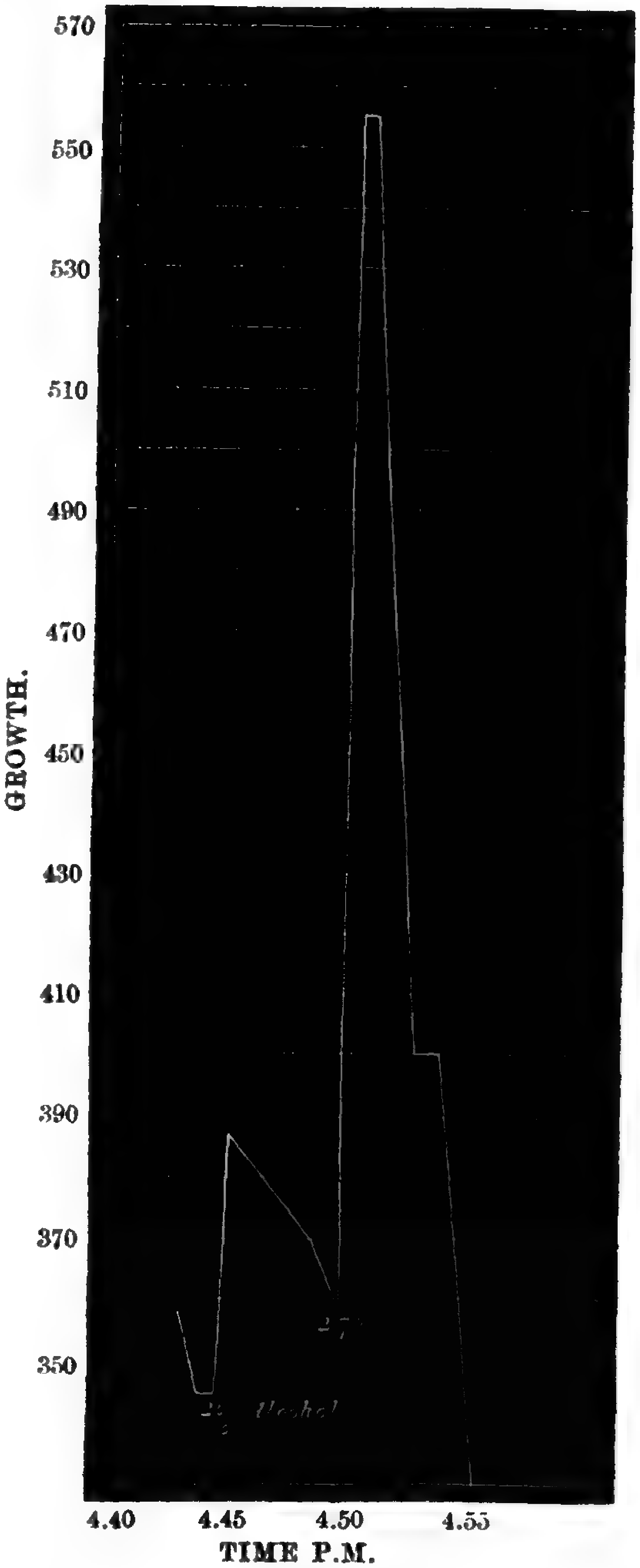


Diagram: Effects of Alcohol.

Exp. 9.—July 29, 1886. Dandelion; screw method.

Times of observation.	Rate [*].
A.M.	
11.39	76 (in water).
	76
	85
11.42·5	66
	Transferred to a jar of 3 per cent. alcohol.
	71
	47
	26
11.45	Alcohol added (6 per cent. mixture).
	35
11.46·5	36

Experiment 9 and other similar trials showed that a fresh acceleration of growth can be produced by repeated doses of alcohol. The effect of immersing the pith in pure methylated spirit surprised us much; and is the only result which caused us to doubt whether the alcohol may not act in some inexplicable mechanical way, and not as a stimulus. Pure methylated spirit causes an extremely rapid "growth," lasting for a few minutes, followed, as might be expected, by death and contraction. The only analogous case which we know of is when a split flower-stalk is put in hot water. The stalk continues to curl up violently owing to increased turgescence, and then, as the tissue gets heated throughout, it dies and uncurls. It is not easy to see how the alcohol can stimulate without killing the tissues; and we should have expected that it would have caused contraction, as in the case of other poisons. Although this point is a difficulty, we do not think it fatal to our conclusion that turgescent pith is stimulated to increased growth by alcohol.

2. *Stimulating Effect of Ether Vapour.*

The effects of ether and chloroform on plants is the subject of an extremely interesting paper[†] by Dr. Elfving of Helsingfors. He has shown that ether and chloroform have a stimulating effect on respiration, and a highly remarkable action on the sensibility to light of swarm-spores. He has also tested the effects of the above vapours on the rate of growth of *Phycomyces*; and it is this point which especially interests us. He found that 1 per cent. of ether had no effect, 2 per cent. a distinctly retarding effect, while 5 per cent. brought growth to a standstill, but without killing the hyphæ.

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[*] That is, rate of movement of the index.

[†] Öfversigt af Finska Vetensk.-Soc. Förh. Bd. xxviii.

It will be seen that our results are not necessarily opposed to Elfving's. In the first place, he experimented on a different plant; and, secondly, he does not give any results with percentages lower than 1 per cent. Whereas in our case the stimulating effect of ether was greatest when the vapour was present in strengths *below* 1 per cent.

In our experiments the pith was allowed to "grow" in damp air; in some cases it was previously wetted; but usually pith was employed which had not been so treated. A known quantity of ether was then poured into the jar of known capacity. The mouth of the cylinder was closed by a divided glass disk which allowed the passage of the thread attaching the pith to the lever. The atmosphere of ether was thus kept as constant in strength as was possible.

There can be no doubt that the vapour of ether has a marked accelerating effect.

The following Table shows the percentage of ether in the atmospheres which caused acceleration, the amount of quickening being given in a parallel column:—

Percentage of ether.	Acceleration of growth.
0·27	100 : 118
0·27	100 : 156
0·37	100 : 146
0·40	100 : 200

In raising the strength of the ether by successive additions, acceleration of growth was observed on each addition; but no acceleration was observable when the strength had been raised to about 1·2 per cent.*

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* In one case a very slight acceleration occurred when the strength was suddenly raised from 1·80 per cent. to 4·5 per cent.; and this was quickly followed by contraction and death.

Exp. 10.—Aug. 4, 1886. Jerusalem-Artichoke pith; auxanometer-lever. Cylinder (370 cub. centim.) filled with water, 3.51 P.M.

Times of observation. P.M.		Rate of "growth."
3.51	....	93
		76
3.53	....	In air.
		68
3.54·5	....	60
3.56	......	1 c. c. ether put in, ·27 per cent.
		94
		66

Times of observation. P.M.		Rate of "growth."
3.59	....	59
4.0	....	43
		1 c. c. ether put in, ·54 per cent.
		108
		57
4.48	....	46
4.8	....	26

Fig. 4.

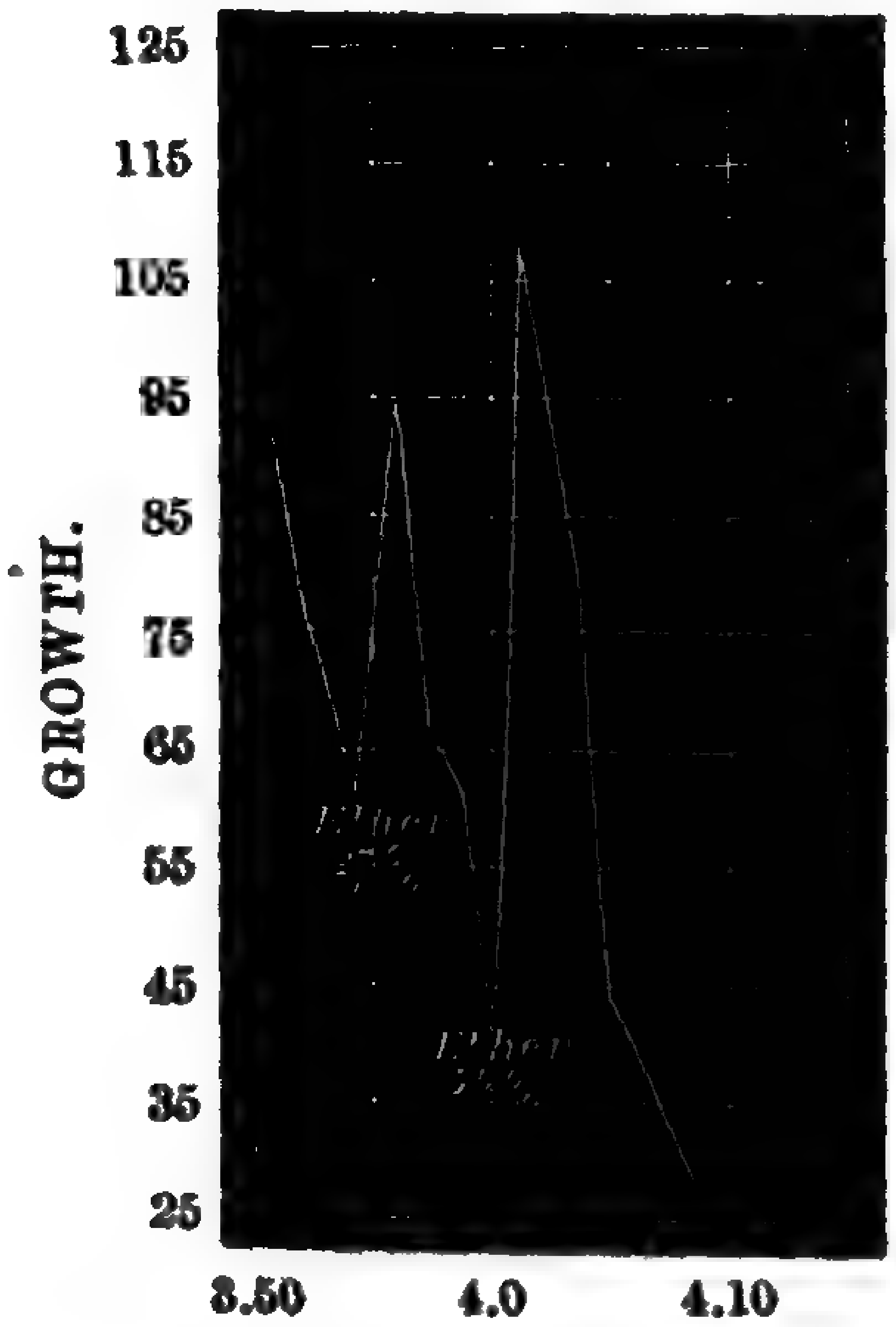

Diagram showing the effect of Ether on the rate of Growth.

Exp. 11.—Sept. 14, 1886. Sunflower-pith; lever.

Times of observation. A.M.		Rate of "growth."	Temperature. ° C.
11.8	....	Pith in damp air (370 c. c.).	20·5
11.8·5	....	250	„
11.12	....	142	„
11.12·3	....	80	„
11.13	....	1 c. c. ether put in, ·27 per cent.	
11.13·5	....	95	20·7
11.14	....	60	„
11.15	....	1·2 c. c. ether added, ·59 per cent.	
		181	„
11.15·5	....	121	„
11.16	....	86	21
11.17	....	48	„

Exp. 11 (continued).

Times of observation. A.M.	Rate of "growth."	Temperature. ° C.
11.17·5	2·6 c. c. ether added, 1·2 per cent.	21
11.18	81	„
11.18·8	53	„
11.20·5	1·2 c. c. ether added, 1·6 per cent.	„
11.22	26	„

Exp. 12.—Sept. 14, 1886. Sunflower-pith; lever.

Times of observation. A.M.	Rate of "growth."	Temperature. ° C.
11.39	In damp air (370 c. c.).	21
11.40·5	49	„
11.42·7	22	„
11.42·8	1·6 c. c. ether put in, ·43 per cent.	„
11.43·5	44	„
11.45·2	42	„
11.46	39	„
11.47	4 c. c. ether put in, 1·5 per cent.	„
11.48	83	„
11.48·5	62	„
11.49	1·6 c. c. ether added, 2·0 per cent.	„
11.50	55	„
11.50·5	43	„
12.1·5	11	„
12.2	10 c. c. ether added, 4·6 per cent.	„
12.6	12	„
12.9·5	Began to shorten.	„
12.11	−13 contraction.	
12.13	−16	„
12.14	Not flaccid.	„

Another method, too rough to admit of accurate determinations, confirmed our results in a general way.

A young flower-stalk (we employed *Chrysanthemum coronarium*) was divided longitudinally, so as to cause the two halves to curl outwards in the usual way. A semicircle of the split peduncle was fixed by one end to a pin stuck into the bottom of a shallow glass vessel. It was so arranged that as the peduncle continued to curl up, its movement was in a horizontal plane. An index of spun glass was fixed to the free end of the peduncle, and the movement of the index measured under a vertical microscope with a low power.

When the rate at which the index was moving across a micrometer-scale had been determined, a drop or two of ether was introduced and a glass cover placed over the vessel. In this way it was easy to observe that :—

(1) Low percentages of ether cause acceleration in the curling up of the curved stalk.

(2) The stimulation can be renewed by repeated additions of ether.

(3) When the amount of ether reaches about 3 per cent., the tissues are killed, and the stalk *uncurls*.

3. *The Effects of Chloroform.*

The pith was placed in damp air in the jar used for the ether work, and the auxanometer-lever was employed to measure the "growth."

We expected to find that, like ether, chloroform would stimulate the "growth" of the pith, since Elfving has found that both these substances stimulate respiration. This, however, was not the case*. In only one experiment did chloroform (about 1·4 per cent.) have any stimulating effect on the "growth" of the pith.

In some cases we found chloroform produce retardation. It is of course difficult to make sure of this result; but when, as in Experiment 17, the fall in the rate of growth is great and sudden, it must be attributed to the effect of chloroform.

The following Table gives some of the results of experiments which are given in detail below :—

Strength.		Effect.
0·008 per cent.	....	Retardation of "growth."
0·05 ,,	....	No effect.
0·07 ,,	....	No effect.
0·1 ,,	....	No effect.
0·9 ,,	....	Slow contraction.
1·0 ,,	.. ..	Slow contraction.

Higher percentages also caused contraction.

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* Ether and chloroform act differently on the respiration of Willow-leaves, inasmuch as the optimum for ether lies between 3 and 7·9 per cent.; while for chloroform it lies between 1·8 and 3 per cent.

Exp. 13.—Aug. 5, 1886. Jerusalem-Artichoke pith; auxanometer-lever.

Times of observation.	Rate of "growth."	Times of observation.	Rate of "growth."
A.M.		A.M.	
10.1·5	In 270 c. c. water.		1 c. c. chloroform, ·37 per cent.
10.3·5	76		
10.4	75	10.11	24
10.6	Water siphoned out.	10.13·3	21
	In air.		1 c. c. chloroform, ·74 per cent.
10.8·8	33	10.17·5	−33 (shortened).
		10.19	−18 ,,

Exp. 14.—Aug. 5, 1886. Sunflower-pith, with auxanometer.

Times of observation.	Rate of "growth."	Times of observation.	Rate of "growth."
A.M.		A.M.	
	In water (370 c.c.).		3–4 drops of chloroform.
10.49	178	10.56	47
	192	10.57	45
	178	10.58·5	33
10.50·5	151	10.59·5	4 drops of chloform.
	Water siphoned out.	11.1·5	26
	In air.		2 c. c. chloroform. Stationary.
10.52·8	67		
10.54·5	41	11.11·5	Began to contract. −16 (shortened).

Exp. 15.—Aug. 23, 1886. Auxanometer; Sunflower-pith.

Times of observation.	Rate of "growth."
A.M.	
11.42	In damp air. Jar of 4770 c. c.
11.43	46
11.44·2	30
11.45	·4 c. c. chloroform, ·008 per cent.
11.46·5	12
11.49	Still growing.

Another Method.—Small pieces of split stalk were observed with a microscope, as described under ether. By this method the results obtained with the auxanometer-lever were roughly confirmed. A single drop or several drops of chloroform were added, and in no case was acceleration visible. With higher strengths growth ceased, and the stalk began to uncurl.

4. *Effect of Camphor.*

An aqueous solution of camphor, said to be 0·1 per cent., was tried; but no effect on the "growth" of the pith was observed. This is contrary to what might have been expected; since camphor is generally considered to have stimulating effects on plants*.

5. *Effect of Ammonia.*

Weak solutions of ammonia were found to have a well-marked stimulating effect. These solutions were prepared by diluting the Liquor Ammoniæ Fortior of the British Pharmacopœia, which contains 32·5 per cent. gaseous ammonia. The auxanometer-lever was used to estimate the rate of growth.

The solutions employed contained percentages of the liquor varying between 0·5 and 2·4 per cent.; and within this range acceleration was produced. The strongest solution employed was 2·4 per cent.; and this did not cause any contraction such as was produced by the higher percentages of ether.

The following Table shows the amount of acceleration produced:—

Strength of solution.	Amount of acceleration.
0·5	100 : 145
0·77	100 : 169
1·9	100 : 103
2·0	No effect.
2·2	100 : 121
2·2	100 : 125
2·4	100 : 129

The experiments are given in detail below.

Exp. 16.—July 31, 1886. Jerusalem-Artichoke pith; with auxanometer-lever.

Times of observation. P.M.	Rate of "growth."	Times of observation. P.M.	Rate of "growth."
	In water.	5.12	·77 per cent.
5·6	476		ammonia.
	416		526
	384		476
	370		484
	370	5.14	416
5·9	333	5.17	232
	322		

Result: acceleration.

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* See Darwin's 'Insectivorous Plants,' p. 209.

Exp. 17.—Aug. 3, 1886. Jerusalem-Artichoke pith; auxanometer-lever.

Times of observation.	Rate of "growth."	Times of observation.	Rate of "growth."
P.M.		P.M.	
5.12·5	129	5.19·5	2·2 per cent. ammonia.
	125		
	104		74
5.15	104	5.22	71
5.18	66	5.23·5	66
5.19·5	56		

Result: slight acceleration.

Exp. 18.—Sept. 7, 1886. Jerusalem-Artichoke pith; lever.

Times of observation.	Rate of "growth."	Temperature.
P.M.		° C.
3.31	370 c. c. tap-water.	18·5
3.31·5	172	„
	153	„
3.32·5	153	„
3.33·6	138	„
3.34	133	„
	0·2 c. c. ammonia added (=2·4 per cent.).	
3.35	166	„
	172	„
3.35·5	166	„
	149	„
3.36	153	„
3.36·5	138	„
3.37	128	„

Result: acceleration.

In the following experiment the effect of ammonia in the form of vapour is shown.

Exp. 19.—July 31, 1886. Jerusalem-Artichoke pith; with auxanometer-lever.

Times of observation.	Rate of "growth."	Times of observation.	Rate of "growth."
P.M.		P.M.	
	In water.	4.42	0·5 per cent. ammonia.
4.38	476		
	454		500
4.40	384		476
	Water siphoned out.	4.44	500
	In air.		384
	344		

It will be seen that the acceleration produced by ammonia is extremely temporary; and in this its action resembles that of ether and alcohol.

EFFECT OF ACIDS.

Various acids were tried. As a rule, they had no accelerating effect on growth; but caused either retardation or actual contraction of the pith.

6. *Effect of Acetic Acid.*

The lower percentages, viz. 0·5 per cent. and 1 per cent., had a retarding effect. Stronger solutions, viz. 1·6 per cent., 3·2 per cent., 3·1 per cent., and 4·4 per cent., produced no effect. When the percentage is raised to 5·4 per cent., the pith contracted after 10 to 20 minutes, and was killed by the treatment.

Exp. 20.—Sept. 9, 1886. Jerusalem-Artichoke pith; lever.

Times of observation.	Rate of "growth."	Temperature.
A.M.		° C.
11.57	Tap-water in.	17·5
11.59·5	153	,,
12.0·0	140	,,
12.0·5	121	,,
12.0·7	Siphoned out water.	
12.2·5	Put in 1 per cent. acetic acid.	,,
12.3·5	28	,,
12.5·0	20	,,
12.7·1	24	,,
12.8·5	25	,,
12.11	16	,,

Result: retardation.

Exp. 21.—Sept. 9, 1886. Jerusalem-Artichoke pith; lever.

Times of observation.	Rate of "growth."	Temperature.
A.M.		° C.
10.14	370 c. c. tap-water.	15·5
10.16	200	,,
10.19	243	,,
10.20	208	,,
10.22	161	,,
10.22·5	153	,,
10.22·5	1·8 c. c. acetic acid (·5 per cent.).	16·5
10.24	72	,,
10.24·5	62	,,
10.25	2·2 c. c. acetic acid added (1 per cent.).	,,
10.27	39	,,
10.33	36	17
10.33·5	7·6 c. c. acetic acid added (3·1 per cent.).	,,
10.34·5	32	,,
10.36·2	25	,,
10.46·8	22	17·5

Exp. 21 (continued).

Times of observation.	Rate of "growth."	Temperature. °C.
A.M.		
10·47·5	10 c. c. acetic acid (5·6 per cent.).	17·5
10.48·5	39	„
10.51·5	10	„
10.57	Began to shorten.	„
11.0·1	—6 (contracts).	„
11.9	Continues to contract.	„

Result: retardation, then contraction.

7. *Effect of Hydrochloric Acid.*

The percentages employed were 0·4 per cent., 0·5 per cent., 2 per cent., and 4 per cent. The effect of 0·5 per cent. was decided retardation. The same effect was obtained with the other percentages, though less markedly.

Effect of 0·4 per cent. = 100 : 51
„ 0·5 „ = 100 : 30
„ 2 „ = 100 : 64

In none of these cases was any stimulation of growth caused by hydrochloric acid; neither was any contraction apparent with these percentages.

Exp. 22.—Aug. 3, 1886. Jerusalem-Artichoke pith; auxanometer.

Times of observation.	Rate of "growth."
P.M.	
5.9	243
	222
	222
	Hydrochloric acid added (=0·4 per cent.).
5.10	114
	129
	129

Result: retardation.

Exp. 23.—Sept. 9, 1886. Jerusalem-Artichoke pith; lever.

Times of observation.	Rate of "growth."	Temperature. °C.
P.M.		
3.2	Tap-water put in.	16
3.3·5	500	„
	400	„
3.4	357	„
3.9	125	„
3.9·5	123	„
3.10	Siphoned out water.	„
3.12	·5 per cent. hydrochloric acid put in.	16·5
3.12·5	38	„
3.14	40	„
3.15	36	„

Result: retardation.

8. *Effect of Nitric Acid.*

The effect of nitric acid was not very evident. Five experiments were tried with this acid. The percentages used were 1 per cent. in three of these experiments, and ·8 per cent. and ·54 per cent. in the other two. On one occasion 1 per cent. had a markedly stimulating effect; but this was not confirmed by the other two experiments; for in one of these 1 per cent. caused a marked retardation of the rate of growth, and in the other it caused a sudden contraction, followed immediately by further growth; ·8 per cent. had no marked effect; and ·54 per cent. caused a distinct retardation.

·54 per cent.	100 : 44
·8 ,,	100 : 52
1 ,,	100 : 259
1 ,,	100 : 44
1 ,,	Contraction.

9. *Effect of Carbolic Acid.*

The percentages used were 0·5 per cent., 1 per cent., and 3 per cent. The two lower percentages did not appear to have any effect; but 3 per cent. caused a contraction of the pith. In one experiment with 3 per cent. carbolic the contraction was very rapid; and the pith, on being freed from the auxanometer, was flaccid, and did not recover its turgidity on being placed in water.

Exp. 24.—Sept. 10, 1886. Jerusalem-Artichoke pith; lever.

Times of observation. P.M.	Rate of "growth."	Temperature. ° C.
12.10	Tap-water.	16·5
12.11	105	,,
12.11·5	105	,,
12.13	113	,,
12.14	108	,,
12.14·2	95	,,
12.14·5	Siphoned out water.	,,
12.16	3 per cent. carbolic acid added.	,,
12.17	Began to shorten. Shortened 1 millim.	,,
12.28	Not flaccid.	,,

The result is interesting, as showing how rapidly the poison takes effect in causing contraction.

Exp. 25.—Sept. 10, 1886. Jerusalem-Artichoke pith; lever.

Times of observation.	Rate of "growth"	Temperature.
A.M.		° C.
11.50	Tap-water put in.	16
	166	"
11.51	153	"
	181	"
	192	"
11.52	181	"
11.53	200	"
11.55	161	"
11.55·5	147	"
	Siphoned out tap-water.	"
11.57	3 per cent. carbolic acid (aq. sol.) put in.	18
11.58	−47 (5 millim.) (contraction).	"
11.59	−248 (contraction).	"
12.1	Flaccid.	"

Result: almost instantaneous contraction.

10. *Effect of Hydrocyanic Acid.*

The effect of prussic acid is very striking. It did not produce a contraction such as is caused by carbolic acid, and such as might have been expected, but either a temporary acceleration (comparable to the effect of alcohol), or else a remarkably steady high rate of growth continued for a prolonged period. Weak solutions were obtained by diluting the pharmacopœial preparation, which contains 2 per cent. of the acid.

Exp. 26.—Aug. 24, 1886. Sunflower-pith; lever.

Times of observation.	Rate of "growth."
A.M.	
11.48	370 c. c. water.
11.54	52
11.56	59
11.57	54
11.59	52
11.59·5	Prussic acid, 3 c. c. put in, 0·8 per cent.
12.1	42
	45
12.2·5	46
	44
	41
	44
12·6	39
	37
A.M.	
12.13	34
	Siphoned out solution.
12.15	1·4 per cent. prussic acid.
12.16·5	40
	36
12.18	37
	37
12.20	38
	37
12.29	41
12.38·5	37
12.52	30

Exp. 27.—Aug. 22, 1886. Sunflower-pith; lever.

Times of observation.	Rate of "growth."
A.M.	
10.17·5	370 c. c. cold water.
10.21·5	37
10.22·3	37
10.26	32
10.26·5	Prussic acid, ·2 per cent.
10.28·5	30
10.29·5	29
10.30·7	30
10.32·0	29
10.36·5	Prussic acid 1 c. c. added (·47 per cent.)
	27
	26
10.37	Prussic acid 1 c. c. added (1 per cent.).
	29
10.40	28
10.41·5	28
	28

Times of observation.	Rate of "growth."
A.M.	
10.45	33
	33
	36
10.48	36
10.49	34
	38
	38
	39
10.52·2	42
10.53·1	35
	39
10.55	38
10.56·5	45
10.57·2	40
	41
10.59	42
11.0	42
11.4	38
11.6	34
11.7	32
	33
11.9	28
	Not flaccid.

Fig. 5.

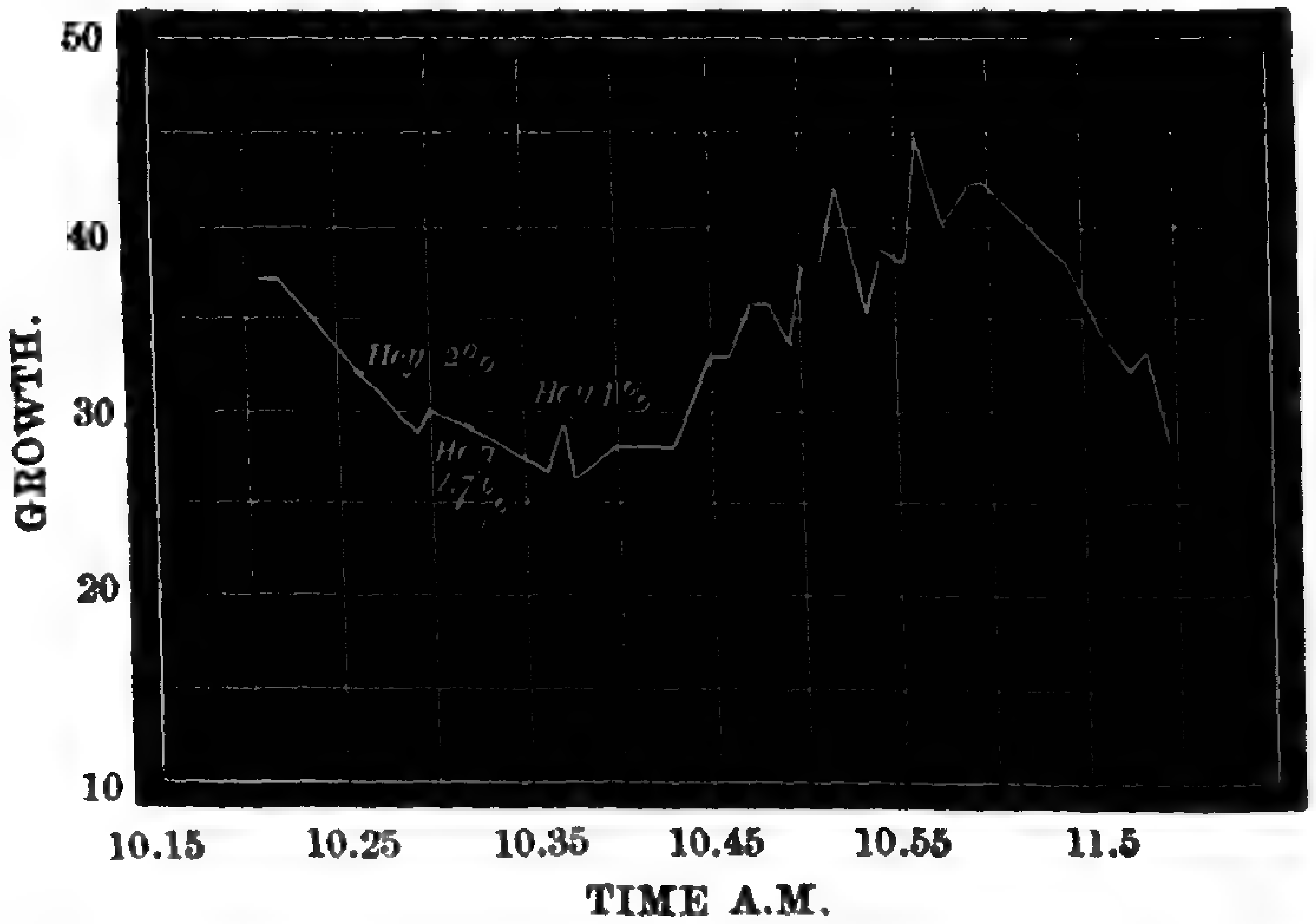

Diagram showing effects of Prussic Acid.

It will be seen that before the prussic acid was added the growth was rapidly slowing down, and that the effect of the addition was to cause an acceleration continued for half an hour, very different in character to that sudden rise caused by alcohol and ether.

11. *Effect of Quinine.*

Dilute aqueous solutions of quinine chloride were used, ranging between 0·15 and 0·34 per cent.

In two cases 0·15 per-cent. and 0·2 per-cent. solutions produced accelerations of 100 : 110 and 100 : 141. In the majority of cases, however, quinine had either no effect, or rapidly caused a contraction of the pith. In two cases with 0·3 per cent., in one with 0·34 per cent., and one with 0·15 per cent., no effect was produced. In four cases (0·42 per cent., 0·34 per cent., 0·15 per cent., 0·1 per cent.) contraction was produced. The results are therefore of a doubtful character.

Exp. 28.—Aug. 26, 1886.

Times of observation. A.M.	Rate of "growth."	Temperature. ° C.
10.40	Tap-water put in.	18
	238	"
10.48	217	"
10.49	192	"
10.49·5	Siphoned out water.	"
10.50·2	Quinine ·34 per-cent. solution put in.	17·5
	166	"
10.52	138	"
10.53·5	44	"
10.56	32	"

Result: no effect.

Exp. 29.—Aug. 26, 1886. Sunflower-pith; lever.

Times of observation. A.M.	Rate of "growth."	Temperature. ° C.
11.20	Tap-water put in.	18
	263	"
	263	"
11.23	256	"
	Siphoned out water.	"
11.25	Quinine ·34 per-cent. solution.	18·5
11.26	108	"
11.26·5	100	"
11.27·2	68	"
11.29	Began to shorten.	"
11.31	−25 (contraction). Flaccid.	"

Result: retardation, followed in a few minutes by contraction and death.

Exp. 30.—Aug. 22, 1886. Sunflower-pith; lever method.

Times of observation.	Rate of "growth."	Times of observation.	Rate of "growth."
A.M.		A.M.	
11.37·5	Tap-water put in.	11.47·5	Siphoned out water.
11.38·5	89	11.48·5	·42 per cent. quinine solution put in. Shortened immediately.
11.39	95	11.49·5	−81 (contracts).
	113	11.50·5	−136 „
	111	11.58	Stationary. Flaccid.
11.42	117		
	109		
11.43	105		
11.47	58		

Result: immediate contraction and death.

Exp. 31.—Sept. 14, 1886. Jerusalem-Artichoke pith; lever.

Times of observation.	Rate of "growth."	Temperature. ° C.
P.M.		
12.34	Water put in.	23
12.35	270	„
12.36	285	„
12.36·7	192	„
	200	„
12.38	166	„
12.38·5	153	„
12.40	125	„
12.43·5	84	„
12.46·5	Siphoned out water.	23·5
	1 per-cent. quinine solution.	20
	Shortened immediately.	
12.47·2	−147 (contracts).	„
12.49	− 69 „	„

Result: immediate contraction.

EFFECT OF PLASMOLYSIS.

On this point our experiments are incomplete; and we can do no more at present than call attention to what we are inclined to think a curious point. Solutions of common salt or of KNO_3 are shown by De Vries to produce contraction of turgescent tissues; and we naturally expected that they would therefore produce a shortening such as would be indicated by an upward movement of the long arm of the auxanometer-lever; but this was not the case. We have seen that carbolic acid, quinine, acetic acid, &c. produce a contraction strong enough to depress the short arm of the lever; and we cannot explain how it is that the same effect is not produced by solutions of salts sufficiently concentrated to produce plasmolysis.

SUMMARY.

The following are the more important results obtained:—

(1) Turgescent pith placed in water increases in length, at first slowly, then more quickly; and then again the rate of increase becomes slow.

(2) The rate of increase in length increases as the temperature of the water rises, reaches an optimum, and suddenly falls as a temperature sufficient to cause flaccidity is approached.

(3) The following reagents cause distinct acceleration:—Alcohol, ether, ammonia, hydrocyanic acid. The first three cause a very temporary effect, whereas prussic acid has a prolonged action.

(4) The following reagents produced retardation:—Acetic acid, hydrochloric acid, and probably nitric acid.

(5) Dilute solutions of quinine chloride, and of carbolic acid, produce a remarkably rapid shortening of the pith.

Observations on the Genus *Ficus*, with special reference to the Indo-Malayan and Chinese Species. By G. KING, M.B., LL.D., F.L.S., Superintendent Royal Botanic Garden, Calcutta.

[Read 17th March, 1887.]

THE genus *Ficus* was founded by Linnæus, and in the first edition of his 'Species Plantarum' he described seven species, four of which are Indian. By the time Sprengel's 'Systema' appeared (1825 to 1828) the number of species had risen to 118, of which 50 were from the Indo-Malayan region. In 1825 Blume's 'Bijdragen' was published, and in it there are descriptions of 93 species of Malayan Figs, of which 82 were described for the first time. Roxburgh's 'Flora Indica,' although completed before the author's death in 1815, was not published until 1832, and in it 55 Indian species are described. Of these species, 41 bore Roxburgh's name as their author; but only about 15 of them had previously been undescribed. Although Gaertner had given a fairly good description of the achenes of *F. Carica* and *F. religiosa*, yet between the time of Linnæus and that of Roxburgh systematic writers had paid but little attention to the structure of the flowers and to the mode of their arrangement on the receptacles, the species being founded purely on external characters. The remarks of Linnæus himself on the common eatable Fig in the 'Hortus Cliffortianus' (published in 1737, the same year as the first edition of his 'Genera Plantarum') show that he had a clearer comprehension of the actual arrangements of the sexes than most of the writers who succeeded him. In the 'Hortus Cliffortianus' Linnæus reduces to the same species the Fig, the Caprifig, and Erinosyce—regarding the Caprifig as the male, the Fig as the female, and *Erinosyce* as the hermaphrodite form of one and the same species. In the first edition of the 'Species Plantarum,' Linnæus put the genus *Ficus* in his class *Cryptogamia*; but in the second edition he transferred it to *Polygamia Polyœcia*, thus confirming the view as to the nature of the arrangements of the flowers of the common Fig which he had expressed in the 'Hortus Cliffortianus.' In the second volume of his 'Enumeratio' (1806), Vahl puts *Ficus* into *Triandria Monogynia*, thus showing that he not only completely misunderstood the sexual arrangements, but that he could never have even counted the stamens. In Sprengel's edition of Linnæus just quoted, *Ficus* is put into a section of *Monœcia* called *Androgynia*, from the supposition that flowers of each sex are found in each receptacle. The character of the genus given by Blume in his 'Bijdragen' shows that he must have adopted Vahl's definition without examination of the flowers; for, according to Blume, as to Vahl, the male flowers of the genus are triandrous. Blume mentions that the males have a rudimentary pistil, which, as a matter of fact, is the case in only a small number of species. Roxburgh is the first writer who attempts to describe the flowers of each species; and in a note attached to his definition of the genus in his 'Flora Indica' he says:—"I have examined minutely the florets of nearly the whole of the species, and found only two instances in which they were not androgynous, and by far the greater part are monandrous." He therefore puts *Ficus* into *Monœcia Monandria*. Gasparrini and Miquel were the next botanists who appear to have made a careful study of the flowers of the genus. In the year 1844 Gasparrini published a remarkable paper, in which he divided all the species of *Ficus* known to him into eight genera, viz. *Ficus* proper, *Caprificus*, *Tenorea* (a name subsequently changed by himself to *Macrophthalma*), *Urostigma*, *Visiania*, *Cystogyne*, *Galoglychia*, and *Covellia*. His first genus, *Ficus* proper, contained only one species, namely the common eatable Fig of Southern Europe. His second genus, *Caprificus*, contained only the Caprifig, which, as Linnæus had maintained more than a hundred years before, and as the most recent observations have demonstrated, is only the male of the plant of which the eatable Fig is the female. Gasparrini's genus *Tenorea* contained only a single species, the *F. pumila* of Linnæus. His fourth genus, *Urostigma*, is the only one of his groups which has stood the test of experience; it contained all the species known to Gasparrini of the group as defined in the following pages. Into his fifth genus, called *Visiania*, Gasparrini put only a single plant, viz. *F. elastica*, a species referred by all subsequent writers to *Urostigma*. The sixth genus contained a single species, *F. leucosticta*, a species which I have referred to *Covellia*. *Galoglychia*, Gasparrini's seventh genus, consisted of two species, which, being American, lie beyond the scope of the present paper. To Gasparrini's eighth genus, *Covellia*, he referred only a single species, of which he says he had neither seen male flowers nor ripe seeds.

During the same year (1844) in which Gasparrini's new classification was published, Miquel, in the 'Ann. des Sciences Naturelles,' série 3, i. p. 31, working chiefly on some of Roxburgh's descriptions, suggested that the species described in the 'Flora Indica' of that author ought not to be considered as forming a natural homogeneous group, but as divisible into very distinct sections; and in the same paper he proceeds to distribute twenty-five of them into the two sections *Carica* and *Sycocarpus*, while on one of the species (*F. hispida*, syn. *F. oppositifolia*) he founds the new genus *Sycomorphe*. The basis of Miquel's (as of Gasparrini's) classification was the structure and disposition of the flowers. Three years later (*i. e.* in 1847) Miquel began to publish, in Hooker's 'London Journal of Botany,' a monograph of all the species of the old genus *Ficus*, and as the result of his extended study of it he established the following genera:—*Urostigma*, including 167 species; *Pharmacosycea*, including 12 species; *Pogonotrophe*, including 16 species; *Sycomorus*, including 12 species; *Ficus*, including 138 species; *Covellia*, including 31 species; *Synœcia*, including 2 species. These seven genera were formed solely on characters obtained from the structure and disposition of the flowers, the number of the stamens and the character of the stigma forming prominent features in the diagnoses. Some of the characters were founded on undoubted errors of observations, as, for example, when the female flowers of *Covellia* and those of both males and females in *Synœcia* are described as without perigonium. This arrangement was subsequently abandoned by its author, and Miquel himself, twenty years later (in 1867), published in the Ann. Mus. Lugd.-Bat. vol. iii., a rearrangement of *Ficus*. In this new arrangement Miquel abandoned the idea of breaking up the genus *Ficus* into genera, and substituted for that scheme one in which the reunited genus is subdivided into six subgenera, as follows:—*Urostigma*, with 143 Old-World, 110 American species, and 21 of doubtful nativity; *Pharmacosyce*, with 18 species, all American; *Erythrogyne*, with 2 species; *Synœcia*, with 3 species; *Eusyce*, with 209 species; *Covellia*, with 48 species. In this rearrangement three of Miquel's old genera—*Urostigma*, *Pharmacosyce*, and *Covellia*—appear, with enlarged and slightly altered characters, as subgenera. The name of a fourth old genus, *Synœcia*, is kept up for a subgenus; but the name only, for a totally different set of characters are given to the subgenus from those which characterized the genus; whilst two entirely new subgenera, viz. *Erythrogyne* and *Eusyce*, are established. The total number of species included in this second enumeration of Miquel's is 405 Old-World species, 128 American species, and 22 species of doubtful nativity. In this second arrangement of Miquel's the flowers alone are not trusted to entirely for the subgeneric characters, but account is also taken of the form and situation of the receptacles, of the form of the leaves, and of general habit.

In the 'Genera Plantarum' of the late Mr. Bentham and Sir J. D. Hooker, four of Miquel's subgenera, viz. *Urostigma*, *Eusyce*, *Synœcia*, and *Covellia*, are admitted. *Pharmacosyce* (a diandrous group of *Urostigma*-like species) is accepted with doubt, and the sixth, *Erythrogyne*, is suppressed. But these eminent botanists admit that the sections which they adopt from Miquel are too loosely defined, and they commend the whole genus to the attention of the monographer. This advice, together with the kind personal encouragement of Sir Joseph Hooker, induced me to carry through an attempt which I had begun a year or two previously to elucidate the structure and affinities of the species of *Ficus* found in the Indo-Malayan region.

The flowers of the genus *Ficus* are collected in a cymose manner on a fleshy axis, which, by the curving upwards of its circumferential part (or organic base), is converted into a kind of flask, on the inner surface of the walls of which a number of flowers are arranged. As the bottom of the interior of the flask corresponds to the apex of the axis, the flowers developed there are the oldest, while those developed nearest the mouth (the organic base) are the youngest. These flower-bearing axes are called figs, receptacles, or amphantha. They vary in colour, form, size, and in the situation which they occupy on the plant. In some species of the section *Urostigma* the receptacles while young are enclosed in calyptriform involucres, which are thrown off at an early stage of the expansion of the receptacles. These hood-like bodies persist longer in *F. altissima* than in any other species, but on the whole they are too fugacious to found specific characters upon. The hollow receptacle has walls of more or less fleshy texture, and its mouth is occupied by rows of bracts, which in the majority of cases so interlock as practically to close it. The lower of these bracts often bend downwards into the cavity of the receptacle, curving round the upper flowers; the middle bracts are more or less horizontal in direction, while those towards the upper or outer part of the mouth project therefrom, so as to be visible externally and to form a more or less prominent apical umbilicus. In a few species the mouth is surrounded externally by a more or less clearly defined annulus, formed of coalesced bracts. In shape the receptacle varies from spheroidal to ovoid, ellipsoid, obovoid, or pyriform. In most species involucral bracts are found at the base of it; these bracts are usually three in number, and are generally distinct from each other, but sometimes they are slightly united, so as to form a kind of involucral cup. The receptacle in many species is contracted at its base, and in some this contraction is carried to such an extent that a kind of false stalk is formed. This stalk-like contraction must not, however, be confounded with the peduncle proper, by which, in many species, the receptacle is attached to the axis; and, as a fact, the stalk may invariably be distinguished from the peduncle proper by the position of the involucres just referred to, which are attached at the apex of the peduncle proper, but at the base of the pseudo-stalk. As regards situation, receptacles may occur in pairs in the axils of the leaves (e. g. *Urostigma*), or they may be solitary in the same situation from the abortion of one of the original pair (e. g. *Synœcia*); they may also occur in axillary fascicles of three or more. In a large number of species (e. g. *Neomorphe*) the receptacles are borne on tubercles (*i. e.* shortened leafless branchlets) from the larger branches or from the stem: while in one set of species (*Covellia*) the receptacles are borne on long, subaphyllous branches, which, proceeding from the stem near its base, either trail along the surface of the ground or bury themselves in the soil. In one very remarkable species (*F. Minahassæ*) the receptacles are collected in dense capitula, which in turn are arranged in long leafless branches which droop towards, but hardly reach, the ground. In a few species (e. g. *F. hispida*) receptacles occur both in the axils of the leaves and on stem-tubercles. In size, as in colour, the receptacle varies much, and excellent specific characters are derived from these differences.

The flowers, which are mostly unisexual, are situated on the inner walls of the receptacle; they may be either sessile or pedicellate. In some species they are separated from each other by scales or bracteoles, and in others by hairs, both of which appendages appear to be analogous to the *paleæ* that are found on the receptacles of many Compositæ. In other species the flowers lie close together, unseparated by any intervening appendages. Five kinds of flowers are found in the genus, viz. male, pseudo-hermaphrodite, neuter, fertile female, and gall flowers. The structure of each of these is very simple. The male flowers consist of a perianth of from 3 to 5 pieces, which, although sometimes united, are usually free. The perianth sometimes hardly covers the stamen or stamens; in other cases it is large, inflated, and completely envelops the stamen. In some species the pieces of the perianth are thin and colourless and not unfrequently hyaline; in others they are of a red or dark-brown colour and opaque. In quite half the Indo-Malayan species there is only a single stamen; in very many there are only two; while in only a few are there so many as three. In shape the anthers are for the most part ovate or elliptic, although some are very broad and almost rotund; they are always 2-celled and have sutural dehiscence. Some are sessile or nearly so, and in very few is the filament long. The attachment of the anther to the filament is innate in most species; in a few, however, it is adnate. In the species with two stamens the filaments are often united for the whole or part of their length, leaving the anthers, however, free.

Pseudo-hermaphrodite flowers occur in only a few species. Such flowers have a perianth like the ordinary male flower, but along with the single stamen there is present in them a pistil with completely formed style and ovary. I have, however, never found one of these ovaries to form a fruit containing a seed, but I have not unfrequently found one to contain an insect pupa.

Neuter flowers are found only in the few species forming the section *Synœcia*. They are long-pedicellate and have a 3-leaved perianth, without any trace of either anther or pistil.

Fertile female flowers have a perianth not very different from that of the males, but consisting in many cases of more pieces, and being more often gamophyllous. In the case where the pieces of the perianth are free, the individual pieces are sometimes rather easily detached, and are very apt to be confounded with the bracteoles of the receptacles in species where the latter exist. The perianth is usually much smaller than the mature achene, and covers the latter very incompletely or not at all. In some cases where the perianth is gamophyllous it forms a small cup, which surrounds only the base of the ovary or its pedicel. It was in some such cases, where the perianth is hyaline, that Miquel was led to believe that none existed; and hence his statement about the perianth being absent in *Covellia*. The pistil may be sessile, but it is very often pedicellate; the ovary is more or less ovoid or obovoid, with a tendency to be emarginate on the side at which the style is attached; it contains a single pendulous ovule. The style is filiform, and is in most cases distinctly lateral or subterminal; it rarely springs from the apex of the ovary. In length the style usually greatly exceeds the ovary; it is usually smooth, but in a few species it is hairy. The stigma, which is papillose, varies in shape, being cylindric, clavate, capitate, peltate, or infundibuliform; and in a few cases it is flat. In many species it is obliquely truncate, and in not a few bicrural. It is, however, often very difficult to determine the exact form of the stigma, from the fact that at an early stage the stigmas of all the fertile female flowers of the same receptacle are joined together in a dense felted mass, from which it is nearly impossible to detach any individual in a state of entirety. After fertilization the ovary becomes developed into an achene, which tends to be unilaterally emarginate (many achenes are very distinctly reniform), and the style becomes more lateral, or even basal. The ripe achene has a crustaceous pericarp of a pale yellow colour and with a more or less minutely tuberculate or undulate surface. External to the crustaceous coat there is occasionally a glairy or viscid layer. The pericarp is never very thick, and sometimes it is conspicuously thin. On cutting the seed open the embryo is seen with a small amount of albumen; I have not, however, paid much attention to the relation of the albumen to the embryo. Not a few of the perfect female flowers fail to be fertilized; but the fact of the barrenness of such is not recognizable until the achene has been cut open, and it is found to contain no embryo. Externally these barren achenes exactly resemble those containing seeds.

Besides the above four kinds of flowers, there occur in all the species of *Ficus* which I have examined a set of flowers which, adopting the name given to them by Count Solms-Laubach, I call *gall*-flowers. My own name for these was originally *insect-attacked females*; but Count Solms-Laubach's name being much shorter and more suitable, I have adopted it. The existence of these gall-flowers in this genus, as a separate and distinct kind of flower, was first made publicly known by the distinguished botanist just mentioned in the 'Botanische Zeitung,' Nos. 33–36 for 1885. My own observations and inquiries on *Ficus* have been in progress since 1878; but on account of my unwillingness to publish anything until I had completed my research, I have been anticipated in the publication of the facts about gall-flowers. The gall-flowers in many respects resemble the fertile female flowers; they have in most cases a similar perianth, an ovary, and a style. When fully developed, they are recognized at a glance by their containing the pupa of an insect, which can often be seen through the pericarp of the false achene into which the ovary develops. But whether the pupa be visible or not, or whether it be present or not, the false achene of the gall-flower may in its later stages be distinguished from the true achene of the fertilized ovary of the perfect or fertile female flower by being more often pedicellate, and by its shape being usually globular and rarely elliptic or reniform; by its surface being smooth, not minutely tubercular or undulate, and never viscid or glairy; and frequently also by the tense distended appearance of its tough membranous wall (false pericarp). The style is, as a rule, much shorter and straighter than the style of the fertile female, and more terminal, and it has very frequently a dilated tubular apex which occupies the situation of the true stigma, but has often little or none of the viscid parenchyma characteristic of that organ. These peculiarities in the nature of the stigma and the shortness of the style are apparent in the gall-flowers of many species from a very early stage. There are, however, many species of *Ficus* (more especially in the group *Urostigma*), in which the gall and fertile female flowers are not characterized by any marked differences in the form of style and stigma, and it it only by cutting the ovaries open that the two can be distinguished.

Now there is probably nothing in itself very remarkable in the mere occurrence in the genus of numerous flowers having the general form of females, which yet, by reason of certain peculiarities in their structure, are incapable of fertilization by pollen and are practically barren, while at the same time their very structural defects fit them for becoming the nidus for the larvæ of special insects. But when the manner in which these malformed female flowers are disposed in the receptacles is inquired into, it becomes clear that through the interposition of insects these malformed females may play a most important part in the life-history of many species of the genus. In all the species, except those included in the section *Urostigma*, the gall-flowers occupy the same receptacles as the males, while the fertile female flowers occupy different receptacles. In other words, the majority of the species have two distinct sets of receptacles—one set containing male and gall-flowers, but no fertile female flowers; and another set containing only fertile female flowers without any trace of either male or gall-flowers. The proportion of males to gall-flowers in receptacles of the former kind varies. In all (excepting the *Urostigmas* just mentioned) it is the rule to find the males confined to a zone of greater or less width at the apex of the receptacle just under the scales which close its mouth. Sometimes this zone is very narrow indeed, and consists of only a single row of male flowers, and that row not always a complete one, the remaining part of the interior of the receptacle being occupied by gall-flowers. In by far the majority of cases these two kinds of receptacles, so physiologically distinct, are undistinguishable by external characters, and they are both borne by the same individual plant. They look exactly alike until one cuts them open and examines their contents. The most notorious of the few exceptions to this rule is the common eatable Fig (*Ficus Carica*), in which species the male and gall-flowers occupy globular receptacles borne in one set of individual trees, while the fertile female flowers occupy more or less elongated receptacles which are borne by a different set of trees. So different in appearance are the two kinds of receptacles in *F. Carica*, that the trees bearing them (although they have similer leaves) have almost from time immemorial been considered distinct species, known by distinct names—the former being called the Caprifig, the latter the Fig. A vague idea of sexual relationship had indeed prevailed even from the time of Aristotle, and on this idea was founded the practice of caprification. Linnæus indeed, in his 'Hortus Cliffortianus,' boldly declared that the Caprifig and Fig were merely male and female of the same species. Linnæus knew that the Caprifig was practically a male, for he says the male Fig (Caprifig) is formed of male florets and of female florets, and of those the females are sterile; the female (Fig) is composed of female florets only. But botanists subsequent to Linnæus regarded the Caprifig and Fig as distinct species; this was Miquel's view, even in his latest rearrangement of the genus; and Gasparrini, as we have seen, formed *Caprificus* and *Ficus* each into a monospecific genus. Another favourite opinion has also been that the two forms are races of one plant, the Caprifig being the wild race and the Fig the race which has been produced by cultivation. This was the view which Count Solms-Laubach maintained and defended with much skill in a paper published so lately as 1882 *. The chief support of this view is really the fact that amongst the gall-flowers of the Caprifig there are occasionally developed perfect female flowers which become fertilized and yield seed. Thus Gasparrini states that, by carefully examining the contents of forty receptacles of Caprifig, he succeeded in obtaining from them twenty achenes with perfect seeds. The view which Count Solms-Laubach at first adhered to was combated by Fritz Müller, who maintained the opinion of Linnæus that the two are but the male and female plants of one and the same species. So impressed was Solms-Laubach by Müller's arguments, that he undertook a journey to Java in order to be able to examine the fresh receptacles of other species with the view of discovering what the disposition of the flowers in these might be. The results he found to be confirmatory of Müller's theory and contradictory of his own, and, with a magnanimous candour, which is unfortunately too uncommon, he publicly abjured his own theory and adopted that of his critic. It was during this investigation that Count Solms-Laubach discovered the true nature of the gall-flowers.

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* "Die Herkunft, Domestication und Verbreitung des gewohnlichen Feigenbaums (*Ficus Carica*, L.)." Von Grafen zu Solms-Laubach. (Aus dem achtundzwanzigsten Bande der Abhandlungen der Königlichen Gesellschaft der Wissenschaften zu Göttingen, 1882.)

F. Carica is not an Indo-Malayan species, but I have referred to it at such length not only on account of the interest that attends the final settlement of a long-pending controversy, but because this species illustrates in an extreme form the arrangements which obtain in a large proportion of the species of the genus. Count Solms-Laubach went to Java expecting that the dimorphism in the receptacles respectively containing the male and female flowers which obtains in *Ficus Carica* would be found to be characteristic of other species; and all through his interesting and remarkable paper in the 'Botanische Zeitung,' to which I have already referred, the influence of this expectation is traceable. As a matter of fact, however, dimorphism in the male and female receptacles is the exception, and in hardly any other case is it so strongly marked as in *F. Carica*.

In the majority of the gall-flowers the pupa of an insect is present, and this pupa can usually be seen through the coats of the ovary. The pupa, when perfected, escapes into the cavity of the receptacle by cutting its way through, or by bursting these coats, and fully developed winged insects are often to be found in considerable numbers in the cavity of the Fig, the opening by which each escaped from the ovary in which it was developed being clearly visible. The pupa of the insect must become encysted in the ovary of the gall-flower at a very early period; for about the time at which the imago is escaping from the ovary the pollen of the anthers of the male flowers is only beginning to be shed. It is quite clear therefore that the synchronism of the two events—the escape of the insect and the maturity of the pollen—is an arrangement of some physiological significance. In the species of *Ficus* in which the arrangement just described obtains (and these are by far the majority), the perfect female flowers are contained in receptacles which are consecrated to themselves alone. In these receptacles the flowers are all perfect females; there is not a trace of a male or of a gall-flower. These receptacles in many species are perfectly closed from a very early stage, and yet, in the majority of cases, every one of the ovaries of the females they enclose contains, when mature, a perfect seed. The exact way in which these females are fertilized is a matter on which I cannot pretend at present to throw any light; I shall only state the problem. The males are shut up from an early age with a number of females, the structure of whose organs is unfavourable to pollenization. No pollen is produced by the males that are shut up with these females until all possibility of their becoming fertile with pollen has been precluded by the encystment within each of their ovarial cavities of the pupa of an insect. On the other hand, a number of perfectly formed females, *all well adapted for the reception of pollen*, are shut up together in a receptacle which contains neither male nor gall-flowers, and to which it is from a very early stage impossible for pollen-bearing insects to get access. Yet each of the females situated in such apparently disadvantageous circumstances bears a well-formed embryo, which develops into a perfect seed.

This arrangement, by which the receptacles are practically diœcious, obtains, as I have said, in a large proportion of the species of *Ficus*. There is, however, a group of species (*Urostigma*) in which it does not obtain, and in which male, fertile female, and gall-flowers are contained in the same receptacle. In this group the difference in structure in the early stages between gall and fertile female flowers is very slight, and in some cases I could find no difference whatever. And even the ripe achenes of the fertile females are in many cases undistinguishable externally from the ovaries containing far advanced pupæ, and it is only by cutting them open that they can be recognized. As regards the relation in this group of *Urostigma* of the male flowers to the fertile female and gall-flowers, there are two types of arrangement. In one set of species (of which *F. bengalensis* and *F. tomentosa* are good examples) the male flowers are comparatively few in number, and are confined to a zone at the apex of the receptacle, just under the ostiolar scales; while in another set the male flowers are intermixed with the fertile female and gall-flowers over the whole surface of the interior of the receptacle.

A third small group (*Synœcia*) has neuter flowers mixed with the fertile females in one set of receptacles; while the other set of receptacles contain only male and gall-flowers. A fourth group (for which I propose the name *Palæomorphe*) has male flowers which, in addition to an anther, contain an insect-attacked or gall-pistil. These pseudo-hermaphrodite flowers are confined to the subostiolar zone, the remainder of the receptacle being occupied by gall-flowers; while perfect female flowers occur in a distinct set of receptacles and are unaccompanied by any trace of male or gall-flowers.

It appears to me that, in the peculiarities in the structure and arrangement of the flowers which I have above described, the evolutionary history of the genus *Ficus* may to some extent be traced. I would therefore venture to arrange the Indo-Malayan species into two great groups, and to divide the second of these great groups into three subgroups, according to their presumed seniority. Believing that hermaphroditism is an archaic and primitive condition from which the genus is in process of delivery, I look on its persistence, even in an imperfect form, as an indication of age. I would therefore separate the ten species in which I find it regularly to occur into a distinct group. Of this group pseudo-hermaphroditism is the diagnostic mark; and to the section which these ten species form I would give the name *Palæomorphe.* It is true that in the whole of these ten species the pseudo-hermaphrodite flowers are confined to the same receptacles as the gall-flowers, while the perfect females are confined to a distinct set of receptacles in which there is no trace of either males or galls, and that the receptacles are thus practically diœcious. Still it appears to me that the persistence of the rudimentary female organ in the male flowers must be taken as indicating a more primitive condition than the enclosure in the same receptacle of strictly unisexual male and female flowers (the arrangement obtaining in *Urostigma*). These ten species being disposed of in a group by themselves, I would form the remaining species of Indo-Malayan *Ficus* into a group characterized by unisexual flowers. And that group I would divide into three subgroups, according as the receptacles are monœcious, pseudo-monœcious, or practically diœcious, the practically diœcious subgroup being again subdivided into sections which are founded on the number of the stamens and the situation of the receptacles. For five of the seven sections into which I would thus throw the Indo-Malayan species I have adopted as sectional designations words previousl in use as sectional or subgeneric names. For the first section, as already stated, I have invented a new name, which indicates what I believe to be its position in the evolution of the genus, and for the seventh I have also invented a new name, indicating its newness in point of evolution. The arrangement is as follows:—

GROUP I.—Pseudo-hermaphrodite; male flowers with 1 stamen and a rudimentary pistil. Pseudo-hermaphrodite flowers and gall-flowers in one set of receptacles; fertile female flowers in another set .... *Palæomorphe.*

GROUP II.—Unisexual or asexual; male flowers without rudimentary pistils.

- SECTION I.—Male, gall, and fertile female flowers on the same receptacle .... *Urostigma.*
- SECTION II.—Flowers unisexual or neuter; male and gall-flowers on one set of receptacles, fertile female and neuter flowers in another set.................. *Synœcia.*
- SECTION III.—Flowers unisexual; male and gall-flowers in one set of receptacles, fertile female flowers only in another set.
  - A.—Flowers monandrous:
    - α. Receptacles chiefly axillary ...... *Sycidium.*
    - β. Receptacles mostly in fascicles from stem and branches .... *Covellia.*
  - B.—Flowers di-, rarely triandrous:
    - α. Receptacles mostly axillary ...... *Eusyce.*
    - β. Receptacles mostly in fascicles from stem and branches .... *Neomorphe.*

These seven sections are not all equally natural. The most natural of them are *Urostigma* and *Synœcia.* The coincidence in *Urostigma* of such apparently unconnected characters as the monœcious condition of the axillary paired receptacles and the epiphytal habit is very remarkable. In no other section is the tendency to be epiphytal at all strongly marked; in *Urostigma* it is universal. Many species in other sections are scandent and support themselves on trees and rocks by throwing out rootlets from their stems and branches. But these rootlets are furnished with fibrillæ and collecting-hairs like the roots that penetrate the soil, and are very different in appearance from the strong subdivisions of the main axis by which the epiphyte embraces, and ultimately strangles the tree to which it attaches itself. The name *Urostigma* was originally devised by Gasparrini; it is the only one of his genera the characters of which pretty nearly agree with those of any of my sections.

The few species which form the section *Synœcia* are climbers with remarkably large and handsome receptacles. The characteristic neuter flowers in all respects resemble the male flowers, except that they have no anther. In one species (*F. apiocarpa*) the neuter flowers are absent. The affinities of that species are, however, so clearly with the others in the section *Synœcia*, that I include it without hesitation, believing it to form a connecting link with the more markedly diœcious sections. The name *Synœcia* is adopted from Miquel, and the characters of his subgenus of that name are nearly those of this section. The section *Sycidium* comprehends a number of species with comparatively small receptacles and rather harsh or scabrid leaves; it forms on the whole a pretty natural section. At the end of it I would put, as a matter of convenience, a few species which belong to different types from the main body. The species brought together in my *Sycidium* are for the most part the same as those which Miquel (who made it a section of his *Eusyce*) included in his *Sycidium*. *Covellia* is a natural section, including two types—one with a tendency to axillary, the other with a tendency to hypogeal inflorescence. The name *Covellia* was originally given by Gasparrini as a generic one to a species of the former type. *Eusyce* is the most artificial of the sections, and the one with which I am the least satisfied; the name was originally given to characterize a subgenus which Miquel founded on rather vague characters. There are several types under the section which, by further study, may be satisfactorily separated into distinct sections. *Neomorphe* is a small and natural section, consisting of species with large receptacles borne on the stem or larger branches. It includes plants which would have gone into Gasparrini's genera *Sycomorus* and *Cystogyne*. In it there is included one species (*F. glomerata*) which, although its affinities are clearly with the other species included in this section, has monœcious receptacles, as in *Urostigma*.

To complete this brief account of the morphology of the genus it is necessary to refer to the remaining organs. The leaves of *Ficus* are for the most part alternate; but in a few species they are opposite. They have a characteristic *facies* of which it is not easy to give an account in words, although it affords ready help both in the field and in the herbarium, when one has become familiar with it. Stipules are universally present, although in some cases they are very fugacious. There are three distinct kinds of so-called "stipules" in the genus. The most truly stipular of these appendages are those which occur in pairs at the origin of the leaves from the axis (one on each side). Examples of this kind are found in many of the scandent species, as for example in *F. lasiocarpa*, and in many of the receptacle-bearing branches in *Covellia*. The second kind of stipule (the so-called "intrapetiolar") is really a kind of leaf-scale occurring only in species with alternate leaves, which, completely embracing the leaf-bearing axis at its base, covers the young leaf and falls off as the latter becomes developed. This kind of stipule attains its highest development in the familiar *F. elastica*, and in that species it persists for an unusually long period. Stipules of the third kind are rarely seen in herbarium specimens; they are really leaf-scales, which are present in considerable numbers as coverings to the leaf-buds in the truly deciduous species (e. g. *F. infectoria* and *F. Tjakela*), as well as in those which, although not deciduous, make their growth only during clearly defined periods (e. g. *F. bracteata*).

The whole of the Indo-Malayan species of which I have seen living specimens contain milky juice except *F. leucantatoma*, and in that species the juice is of a pale buff colour.

Having regard to the foregoing observations, I venture to propose the following amended character for the genus:—

FICUS, *Linn.*

Flowers unisexual (staminiferous, pistiliferous, or gall), or pseudo-hermaphrodite, rarely asexual; collected in various ways on more or less globose ovoid or pyriform concave receptacles which are closed at the apex by numerous bracteoles. Male, gall, and fertile female flowers collected on the same receptacle; or males and galls on a distinct set of receptacles, fertile females and neuters on another set; or males and galls on one set of receptacles and fertile females on a distinct set; flowers often mixed with bracteoles or hairs. ***Male flowers*** with 1, 2, or rarely 3 exserted or included ovate or oblong stamens without rudimentary pistil (except in *Palæomorphe*), the perianth of 2 to 6 distinct pieces, or gamophyllous and 2- to 6-partite, or absent. ***Fertile female flowers*** with a single pistil and without rudimentary stamens, the ovary 1-celled with 1 pendulous ovule, the style more or less lateral, longer than the ovary and surmounted by the clavate cylindric peltate or bifid stigma, the perianth of 2 to

6 distinct pieces, or gamophyllous, 2- to 6-partite, or absent; achenes more or less obovoid or reniform, rarely globular, with a minutely tuberculate or undulate hard pericarp, often with a glairy or mucilaginous outer coat; the seed pendulous, with small albumen, the embryo more or less curved. *Gall-flowers* similar to the fertile females, but not containing embryos, and often occupied by the pupa of an Hemipterous insect; the ovary ovoid or globular, its pericarp thin and membranous, or thick, brittle, and crustaceous; the style shorter than in the fertile female, often dilated above into a more or less trumpet-shaped false stigma. *Neuter flowers* (occurring only in the section *Synœcia*) pedicellate, with perianth like the males, asexual.

Trees or shrubs with milky juice; leaves alternate, rarely opposite, stipulate, entire, serrate, dentate, or lobed, smooth, hairy, or scabrid; the leaf-buds sometimes covered by deciduous leaf-scales. Receptacles usually homo- rarely di-morphous, closed at the mouth by numerous scales arranged in rows, the uppermost of which often partly project externally and form an umbilicus; the base rounded or narrowed and usually subtended by three bracts, sessile or pedunculate, in pairs in the axils of the leaves or of the scars of fallen leaves, solitary by abortion, or in fascicles from tubercles (shortened branchlets) from the main branches or stem, or on long subaphyllous branches proceeding from the stem near its base.

My observations have been made almost exclusively on Indo-Malayan and Chinese species; and in my forthcoming monograph of these species I have arranged them in sections of which the following are the characters :—

I. *Palæomorphe.*—Male flowers with 1 stamen and a rudimentary pistil occupying the same receptacles as the gall-flowers; fertile female flowers alone in another set of receptacles; perianth of fertile females usually gamophyllous (of separate pieces in *F. gibbosa* and *F. Decaisneana*).—Small trees, erect or subscandent shrubs.

II. *Urostigma.*—Male, fertile female, and gall-flowers in the same receptacle; stamen 1 (stamens 2 in *F. callosa* and *F. vasculosa*); stigma elongate, usually acute.—Usually trees or powerful climbers; epiphytal at least in early life; leaves alternate, entire, coriaceous or subcoriaceous, rarely membranous; receptacles in the axils of the leaves or of the scars of fallen leaves, tribracteate at the base (except in *F. Kurzii*, *F. nervosa*, and *F. pubinervis*).

III. *Synœcia.*—Flowers unisexual or neuter; male flowers with 1 stamen; male and gall-flowers in one set of receptacles, fertile female and neuter flowers in another set (neuters absent in *F. apiocarpa*).—Climbers with large coloured receptacles; the leaves tessellate beneath.

IV. *Sycidium.*—Flowers unisexual; male and gall-flowers in one set of receptacles; fertile female flowers in a distinct set of receptacles; male flowers with 1 stamen (stamens sometimes 2 in *F. copiosa* and *F. cuspidata*).—Shrubs, small trees, or climbers; rarely epiphytal; leaves alternate; receptacles small, axillary, more or less scabrid (a few have receptacles in fascicles from the stem).

V. *Covellia.*—Flowers unisexual; male flowers in the same receptacles as the gall-flowers, monandrous, the perianth of 3 or 4 distinct pieces; female flowers in separate receptacles from the males and galls, pedunculate or sessile, the perianth gamophyllous, much shorter than the ovary, or wanting (rarely consisting of 4 or 5 pieces).—Shrubs or trees, never epiphytes or climbers; receptacles on long subaphyllous branches issuing from near the base of the stem, often subhypogæal; or on shortened branchlets (tubercles) from the stem and larger branches; or axillary.

VI. *Eusyce.*—Flowers unisexual, male and gall-flowers in one set of receptacles, fertile female flowers in a distinct set of receptacles (except in *F. Thwaitesii*); male flowers with 2 stamens.—Scandent or erect shrubs or small trees, rarely epiphytal; leaves alternate, softly hairy or glabrous, not scabrid or hispid; receptacles usually small, axillary. (There are 3 stamens in *F. lævis* and *F. nemoralis* and only 1 in *F. lepidosa* and sometimes also in *F. hirta*.)

VII. *Neomorphe.*—Flowers unisexual; male and gall-flowers in one set of receptacles; fertile female flowers in a distinct set of receptacles; male flowers with 2 stamens, the perianth inflated, of 3 or 4 membranous pieces; fertile female flowers smaller than the male or gall-flowers.—Trees rarely scandent, never epiphytal; receptacles often very large, in fascicles from tubercles on the trunk and larger branches.

Disease of *Colocasia* in Jamaica.

By George Massee, Esq. Communicated, with an Introductory Note, by D. Morris, M.A., F.L.S., Assistant Director Royal Gardens, Kew.

[Read 3rd March, 1887.]

(Plate I.)

Introductory Remarks on the Disease of Colocasia in Jamaica.

What are known as "Cocoes" and "Tayas" in Jamaica, "Tanias" in Trinidad, "Tanniers" and "Eddoes" in Barbadoes, form an important element in the food of West-Indian negroes. The different varieties under cultivation in the West Indies are probably referable to *Colocasia esculenta*, Schott.

The genus *Colocasia* belongs to the natural order Aroideæ, and the portions of the plants utilized as food are the stems and shoots from the main stem. These afford, when boiled or roasted, a wholesome and nourishing food, preferred by negroes even to yams and sweet-potato. "Cocoes" are easily cultivated by cuttings from the main stem which, with the terminal bud, are commonly called the "head." They begin to yield in about nine months after planting, and will continue to produce crop for about three years, when the cultivation is either renewed or more likely removed to a fresh locality.

This much, by way of introduction, may usefully explain the value and importance of the following notes prepared by Mr. Massee on a disease which has appeared amongst "Cocoes" in the neighbourhood of Priestman's river, Parish of Portland, Jamaica.

The effects of the destruction of such a food-crop amongst the negroes of Jamaica would be almost comparable to the loss of the potato-crop amongst the peasantry of Ireland. Strange to say, the disease amongst these tropical "Cocoes" is caused by a member of the same genus as the well-known and destructive potato-fungus; and, as it has been found to be a new species, it is named by Mr. Massee *Peronospora trichotoma*.

Although, so far, the disease has only appeared in one locality in Jamaica, it is obviously most important to restrict it as much as possible to that locality.

Remedial measures of a practical character require to be adopted, and these have been recommended to the Government of Jamaica, by whom the specimens examined by Mr. Massee were sent to Kew for Report; but, after all, remedial measures alone cannot be depended upon to eradicate a disease of this character. Experience has shown that the disease must, in the first place, be restricted within the narrowest possible limits; and, in the second place, all badly affected plants should be wholly destroyed. D. MORRIS.

REPORT ON THE DISEASE OF "COCOES" (COLOCASIA) IN JAMAICA.

The disease is due to the presence of a fungus belonging to the genus *Peronospora.*

In the incipient stage, a "tuber" or "head" presents, on transverse section, a number of minute bright yellow spots scattered over its substance, which, at a later period, become brown or blackish, and the intermediate portion tinged brown; eventually the whole tuber, with the exception of a peripheral portion about two lines wide, becomes blackish and decayed, but, so far as we are able to judge from the specimens submitted, remains comparatively dry, and not putrid as in the potato disease, due to the attacks of a fungus belonging to the same genus.

The yellow spots correspond to the vascular bundles, which are always attacked first, the mycelium spreading through the entire substance of the tuber along the cavities of the tracheids, from which it passes to the adjoining parenchyma. The colour is due to the disintegration of cellulose; and the tracheids are frequently ruptured at an early stage owing to excessive development of hyphæ within them.

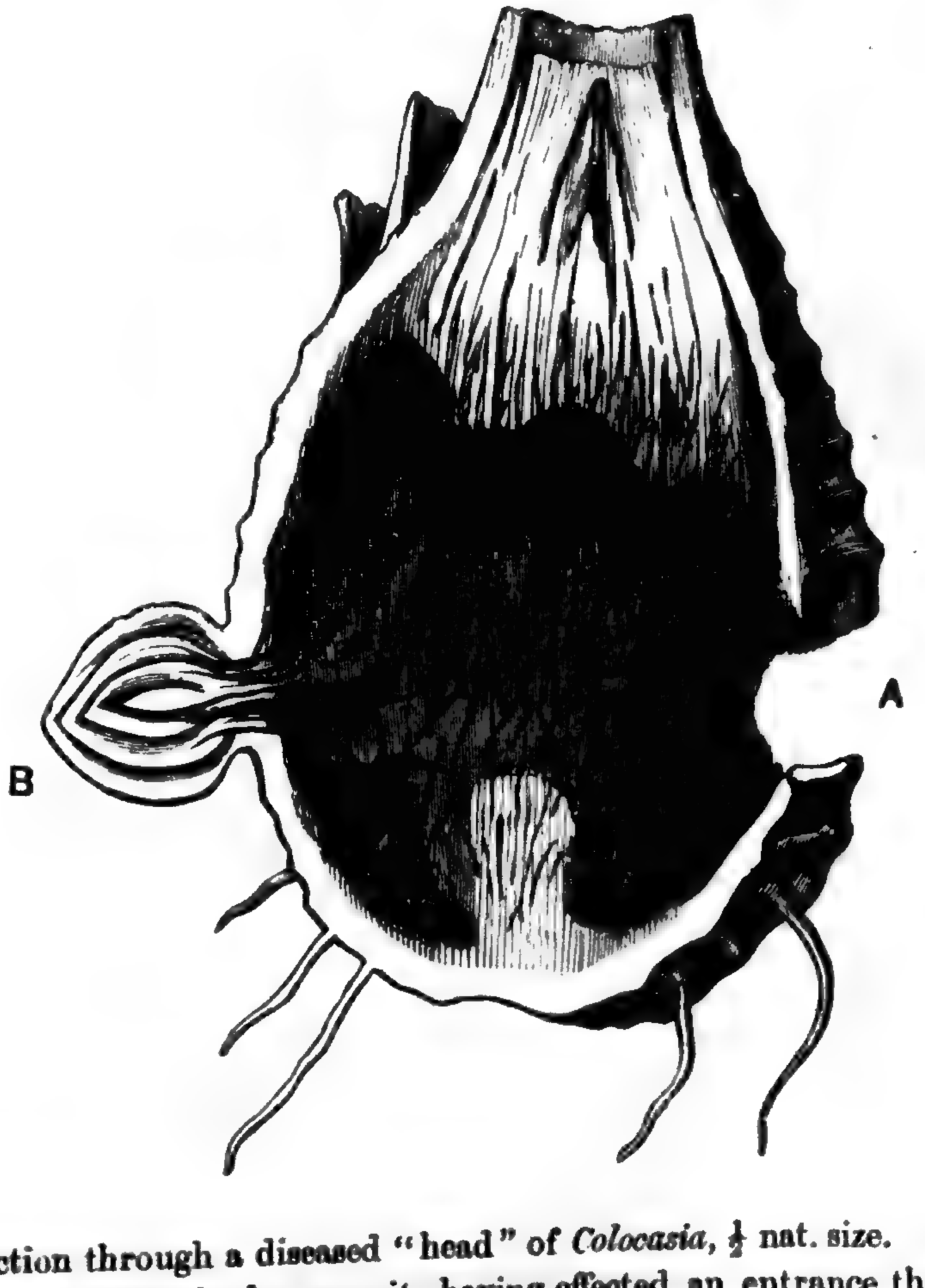
The two forms of reproductive bodies, conidia and resting-spores, were met with: the first are only produced on hyphæ exposed to the air, or in internal cavities; the latter on threads in the substance of the tuber.

The disease is stated to be confined to the tubers, or at all events to show itself there first, and in all the specimens seen it is perfectly certain that an entrance has been effected at a point where the skin had been broken—in one example, where an offset had been broken off; in another through a wound made by some instrument.

We fully believe that the fungus could not penetrate the thick periderm, as is proved by the hyphæ not being able to penetrate it from the inside; and further, if tubers with an unbroken skin could be used for propagation, the disease would speedily be eradicated.

As this method is not practicable, the tubers, after being cut or broken, should remain in a dry place for some time before planting, to allow periderm to develop over the injured portions; or the wounds might be coated with some substance to prevent the entrance of the parasite.

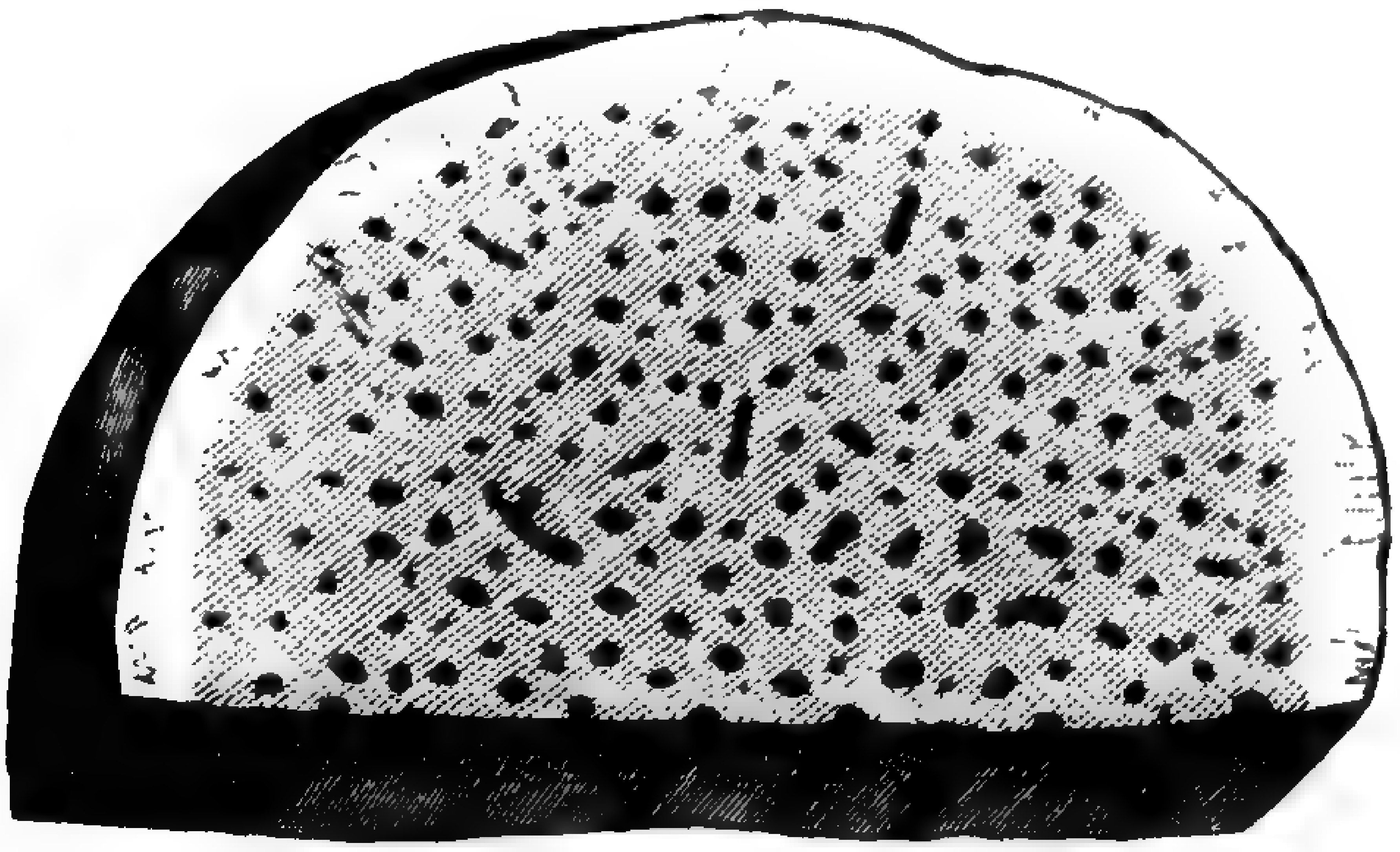
Fig. 1.



Vertical section through a diseased "head" of *Colocasia*, ½ nat. size. The black portion is diseased, the parasite having effected an entrance through the broken surface at A. The hyphæ are penetrating the offset B along the vascular bundles, represented by the dark lines.

The offsets of diseased tubers, even when very young, contain the fungus in their tissues, which are reached by way of the tracheids entering from the parent tuber.

Fig. 2.



Portion of transverse section of head in the early stage of disease; the spots correspond to vascular bundles, the hyphæ having discoloured the walls of the tracheids.

All diseased plants should be burnt, and not buried or used for feeding animals, as the resting-spores possess great power of vitality, and possibly might resist both latter methods of supposed destruction.

PERONOSPORA TRICHOTOMA, *Massee* (Plate I. fig. 1); mycelii tubi crassi, haustoria vesiculiformia, clavata. Stipites conidiferi, fasciculati, 2–3-ies trichotomi. Conidia parva, obovoidea, subglobosa, 12 × 10 μ. Oosporarum episporium fuscum, cristis connexis subregulariter reticulatum, 35–40 μ.

Conidiophores resembling a delicate white bloom on the surface or in hollows of the diseased portions of rootstock of *Colocasia.*

HETEROSPORIUM COLOCASIÆ, *Massee* (Plate I. fig. 2); hyphis fasciculatis, hic inde furcatis, olivaceis; conidiis oblongis, uniseptatis, constrictis, granulatis, pallide olivaceis, 25–30 × 10–12 μ.

Forming olive-green patches on the diseased parts of *Colocasia.*

CEPHALOSPORIUM ACREMONIUM, *Corda*, *Ic. Fung.* iii. p. 29.
Var. with uniseptate conidia. (Plate I. fig. 3.)
Parasitic on the hyphæ of *Heterosporium Colocasiæ.*

The two last-mentioned Fungi are in no way connected with the cause of the disease; but, along with numerous Nematoids, flourished on or in the decaying portions.

DESCRIPTION OF PLATE I.

Fig. 1. *Peronospora trichotoma*, Mass., × 350 diam.
2. *Heterosporium Colocasiæ*, Mass., × 350 diam.
3. *Cephalosporium acremonium*, Corda, var., × 350 diam.

On the Affinities and Classification of Algæ. By ALFRED W. BENNETT, M.A., B.Sc., F.L.S., Lecturer on Botany at St. Thomas's Hospital.

[Read 3rd March, 1887.]

[NOTE.—The type used in printing the names of genera and higher groups has been specially arranged by the author to mark his views as to their relative rank. In this paper, therefore, the usual method of printing such names adopted in this Journal is suspended.—SEC. L. S.]

WHETHER the organisms included for so long under the general name of Algæ form in any sense a natural group, is a question which has been variously answered by different observers and theorisers. About fifteen years ago a system of classification of the Thallophytes was proposed, on authority entitled to the highest respect *, which altogether abolished the bifurcation into Algæ and Fungi. On this system the sole character made use of in their primary classification was the mode of reproduction. First came the Protophyta, in which no sexual mode of reproduction is known, followed by three primary classes (in ascending order)—the Zygosporeæ, Oosporeæ, and Carposporeæ, distinguished solely by the degree of complexity of the sexual process. Each of these four classes was then divided into a series containing chlorophyll and a series not containing chlorophyll, the former including the organisms hitherto known as Algæ, the latter those hitherto known as Fungi.

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* See Sachs, 'Text-book of Botany,' 2nd English edition, p. 244.

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In support of this view it was urged, with great plausibility, that, reproduction being the most important event in the life-history of a plant, the mode in which this is brought about must become fixed in each group by heredity; while such a subordinate character as the presence or absence of chlorophyll is seen in the higher plants to be entirely without importance in determining affinity. But a little consideration will show that it is unsafe to apply the same rule to more highly and to less highly organized forms. In the higher forms of life the mode of sexual reproduction becomes, in its main features, absolutely fixed; and throughout the vast range of Angiosperms—as in the higher animals—there is entire uniformity in this respect in all important points; while in external morphology, and in the mode in which they obtain their livelihood, there is the greatest diversity, even within a narrow circle of affinity. In the animal kingdom we may point, as an illustration of this law, to the existence of such a family as the Cetacea among Mammalia; among flowering plants we have only to consider such phenomena as the occurrence of parasitism, insectivorous habits, or the suppression of chlorophyll, in individual genera dispersed through a large number of natural orders. Even in subsidiary characters connected with the process of reproduction there is not the uniformity that might have been expected. While such an apparently subordinate point as the number of cotyledons in the embryo is so constant as to give its name to primary divisions of Phanerogams, a character which might have been supposed to be much more important (but which, it is instructive to observe, is connected with the mode in which the germinating embryo receives its nutriment)—viz. the presence or absence of endosperm—is not always constant, even within narrow limits. The first necessity of a nascent organism is to live; and hence it is not surprising to find that in the lower forms of life the one character which remains most constant within wide circles of affinity is the mode of life. In the course of development of the higher forms, Nature may be said to have tried a variety of experiments in the mode of reproduction; on the whole there is a continual advance, but still by no means infrequent fallings back to simpler modes; and unless this law of retrogression is taken into account, any system of classification must be *pro tanto* imperfect and misleading.

If these considerations have any weight, it is not surprising that, although the system of classification of Thallophytes above alluded to has been adopted by a few authorities in this country and on the Continent, it has not met with general acceptance. The adoption of its leading principle, that "*in each class* Fungi have diverged as ramifications from various types of Algæ," * is seen to lead to such startling results as the collocation in the same class of Spirogyra and Mucor, of Volvox and Peronospora, of Callithamnion and Agaricus. It may, on the contrary, be safely asserted that several of the most important groups among Fungi (take, for example, the Mucorini, the Uredineæ, and the Basidiomycetes) display no traces of genetic affinity with any known class of Algæ; and if, on the other hand, we have forms like Saprolegnia and Chytridium, or Leptothrix and Beggiatoa among Protophyta, which betray strong indications of a degraded affinity with groups of Algæ, this by no means contradicts the general law that Fungi as a class form an altogether independent series.

Retrogression may take the form of the suppression of either the vegetative or the reproductive organs; and wherever you have one of these sets of organs displaying strong development, while the other set of organs is very feeble or altogether wanting, you have *primâ facie* evidence of retrogression. To take examples from the class of Fungi. It seems highly probable that the Myxomycetes, in which the whole vegetative structure is subordinated to the mode of reproduction, are derived from some higher class of Fungi by retrogressive metamorphosis; while, on the other hand, in many families of the Ascomycetes the sexual organs have partially or entirely aborted; and it is possible that the Basidiomycetes are a class in which this suppression has been still more completely carried out. Examples from Algæ will occur in the sequel.

It is somewhat singular that, if the principle which I have been advocating is sound, it brings us back a long way towards the time-honoured classification, but of late years almost abandoned, of the Algæ into Chlorosporeæ, Rhodosporeæ, and Phæosporeæ—the green, the red, and the brown.

It would appear as if, at a very early period in the development of the simplest forms of vegetable life, three distinct kinds of cell-contents were differentiated, representing three distinct modes of life, and possibly three distinct lines of descent from

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* *Op. cit.* p. 244, footnote.

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the primordial germ—a colourless, a blue-green, and a pure green. The simplest form of the first—entirely destitute of chlorophyll, and adapted to carry on only a saprophytic or parasitic existence—is seen in the Bacteria or **Schizomycetes**. To suppose, however, that Bacteria are the most ancient of all forms of vegetable life involves an obvious contradiction; since the fact of their being saprophytes presupposes the previous existence of living beings of some kind; they must rather have been derived by retrogression from organisms of the second or third class. Be this as it may, from the Schizomycetes are probably directly derived the vast group of FUNGI, the relationships of which to one another are beyond the scope of the present paper. With the highest forms of Fungi this series evidently attained its climax.

The second type consists of unicellular organisms in which the cell-contents are composed of a pale watery blue-green endochrome diffused through the protoplasm, without distinct chlorophyll-grains, starch-grains, or nucleus—the **Chroococcaceæ**, represented by such forms as Chroococcus and Glœocystis. Although these organisms undoubtedly possess a feebly developed power of decomposing the carbonic acid of the atmosphere by means of a substance closely allied to chlorophyll, it is still doubtful whether they contain true chlorophyll, and whether the first products of assimilation are cellulose, starch, or any of the carbohydrates found in the higher plants. Of whatever substance their outer membrane or cell-wall is composed, it manifests a remarkable disposition to become disorganized into an extremely copious coating of gelatin. In Merismopedia we find a tendency towards the development of a plate of cells, and in Cœlosphærium towards the botryoid condition which is so much more strongly displayed in the Protococcaceæ. The Chroococcaceæ have usually a slow power of spontaneous motion in the water, but are never endowed with cilia.

The higher forms of the blue-green Protophyta constitute the group of **Nostochineæ**, characterized by the filiform condition with rudimentary cell-division. The motility of the entire organism possessed by the Chroococcaceæ is now mostly limited to special portions of the filament (the hormogones) endowed with a reproductive function. Starting from the lowest families of the group, the *Oscillariaceæ* and *Rivulariaceæ*, we may suppose after this a bifurcation, in one direction to the *Scytonemaceæ*, in which the thallus for the first time displays true branching, in the other direction to the *Nostocaceæ*, with unbranched thallus composed of moniliform rows of cells enclosed in a copious gelatin, and characterized by the formation of heterocysts which had already begun to be developed in the Rivulariaceæ. With these two families the second series, the PHYCOCHROMACEÆ or CYANOPHYCEÆ, have attained their highest degree of development.

Before passing on to the third series, the position must be discussed of one of the most sharply differentiated but most puzzling groups in the entire vegetable kingdom, the **Diatomaceæ** or Bacillariaceæ. By some writers they are regarded as exhibiting reproduction by conjugation, and are therefore included among the Conjugatæ ; and this view I have myself formerly held ; but am now convinced that the so-called formation of zygospores is but a modification of the formation of auxospores, and is not sexual. The view is certainly plausible that they have descended from the Conjugatæ, and especially from the Desmidieæ, which they resemble in some respects, by retrogressive metamorphosis. But, on the other hand, there are points which tell strongly against this theory. The enormous number and accurate differentiation of species, and their constancy from very remote geological periods, with other considerations, point to the family being a member of an ascending rather than of a descending series. To this must be added their remarkable powers of motion. It is a singular fact, of which one illustration has already been mentioned, that the power of the whole organism to move from place to place (*Ortsbewegung*) is strictly limited to the very lowest members of each series, such as Protococcus, the Chroococcaceæ, and the Schizomycetes. As we ascend, this power becomes localized in special organs, such as zoospores and antherozoids ; until in the most highly developed plants it is almost altogether lost. In no family is this property more strongly and strikingly displayed than in the Diatoms. For these and other reasons I am disposed to look on the Diatomaceæ as very low down in the ascending series, and ranking among Protophyta rather than true Algæ. If this view be correct, they must be regarded as a branch which came to an abrupt conclusion, never arriving at anything higher ; though, owing to the very sharp differentiation of the family, it is very difficult to conjecture where was the starting-point of the branch, possibly in the Cyanophyceæ rather than the Protococcaceæ.

The third series, or CHLOROPHYLLOPHYCEÆ, is the one which alone has developed into the higher forms of vegetable life. It is characterized, from the outset, by the cells possessing a nucleus, starch-grains, pure chlorophyll of precisely the same composition and properties as that of the higher plants, and, in certain states, a true cell-wall of cellulose. In the lowest family, the *Protococcaceæ*, the individuals are unicellular, and motile by means of vibratile cilia, or collected into motionless palmelloid or zooglœoid colonies. Although, as must almost necessarily be the case, the tendency to a higher development in the Protococcaceæ manifests itself in lines parallel to those in the Chroococcaceæ, I cannot but agree with Schaarschmidt that there is, in all probability, no genetic connection between the individual members of the two series. Thus a tendency to develop into a plate of cells similar to that in Merismopedia is displayed also in Tetraspora; and the botryoid association of cells, only rudimentary in Cœlosphærium, is carried out much more fully in Botryococcus.

The further development of the Chlorophyllophyceæ took place in two directions—the perfection and differentiation of the individual cells, and the association of cells into colonies or cœnobes. The latter course may be supposed to start from such forms as Botryococcus; and its first stage is represented by colonies like those of Sorastrum, Cœlastrum, and Selenastrum, constituting the small family of *Sorastreæ*, in which the mode of reproduction is still but little known. In the Sorastreæ the colony moves slowly through the water without being impelled by vibratile cilia. In the next family, the *Pandorineæ*, including Pandorina, Gonium, and Stephanosphæra, we find active motion of the colony by means of cilia, and reproduction by the conjugation of zoogametes. Simpler organisms, like Chlamydomonas and Chlamydococcus, consisting of nothing but conjugating zoogametes, ought possibly to be regarded as retrogressions from the higher forms, though they may also be stages in a direct ascent from Protococcus. Closely allied to the Pandorineæ, and representing another stage in the ascending series, are the *Volvocineæ*. The lowest member of this family, Eudorina, with a rudimentary differentiation of male antherozoids and female oospheres, unquestionably represents the line of development of Volvox, in which this differentiation is more strongly manifested. The Sorastreæ, Pandorineæ, and Volvocineæ are, beyond doubt, nearly related members of one series, the **Cœnobiæ**, although placed, in a purely sexual system of classification, the first in Protococcaceæ, the second in Zygophyceæ, the third in Oophyceæ. In Volvox we have the culmination of the attempt of Nature to evolve higher organisms out of the perfection of cœnobes or motile families of equivalent cells. The *Hydrodictyeæ* are probably an aberrant member of this group; Pediastrum I place elsewhere.

The further differentiation of the individual cell has advanced one stage in the *Eremobiæ* or Characiaceæ, an ill-defined family making up, together with the Protococcaceæ, the group of **Protococcoideæ**, and including such forms as Characium, Apiocystis, Codiolum, and Sciadium. From them the next step is to the group which I propose to call the **Multinucleatæ**, consisting of the *Siphonocladaceæ* and *Siphoneæ*, characterized by each individual consisting of an enormously developed cell, often ramifying greatly and attaining gigantic dimensions, and containing several, often a very considerable number of, nuclei. In the Siphonocladaceæ (placed under Zygophyceæ) the only known mode of reproduction is the conjugation of zoogametes; its lowest member, Botrydium, shows a distinct affinity to Botrydina among the Eremobiæ; higher developments are exhibited in such remarkable organisms as Bryopsis, Codium, Acetabularia, Caulerpa, Valonia, and Rhipelia. The Siphoneæ (usually placed among the Oophyceæ), represented by the familiar genus Vaucheria, are possibly a higher development of the Siphonocladaceæ, in which true sexual organs, oogones and antherids, are formed, in addition to non-sexual zoospores, the reproductive portion of the thallus being now divided off by septa. It is, however, equally probable, or perhaps more so, that the Siphoneæ have been derived directly from the higher Protococcoideæ, and that the Siphonocladaceæ are a group in which the vegetative organs have attained an extraordinary development, while the sexual organs, represented by the oogones and antherids, are altogether suppressed.

The striving after a high development by the elaboration of a single cell culminates in Vaucheria, or in such forms as Acetabularia; but the plan which ultimately proved successful was the formation of a filament of cells by cell-division. In the Cyanophyceæ we have seen a rudimentary exhibition of this structure in the Nostochineæ, but combined with other conditions which prevented its full success there. Where cell-division originated in the Chlorophyllophyceæ is not clear; we find it already fully developed in the Nematophyceæ or **Confervoideæ isogamæ**. The organisms included under this class consist of a single unbranched or branching filament of cells; the only known modes of reproduction being, in most cases, the conjugation of zoogametes and the direct germination of larger zoospores. In the two lowest families, the *Chroolepideæ* and the *Ulotrichaceæ*, embracing a very small number of genera (Chroolepus, Trentepohlia, Ulothrix, and a few others), the filament is usually unbranched; in the two higher, the *Confervaceæ*, including Conferva, Cladophora, Chætomorpha, Draparnaldia, and other genera, and the *Pithophoraceæ*, made up of the single genus Pithophora, further vegetative activity is displayed by the copious branching; and in the Confervaceæ we have again, in some instances, a plurality of nuclei. The exact course of evolution from the isogamous Confervoideæ is obscure; but it would appear to have taken place in three different lines. The first of these, which evidently came to an abrupt conclusion, is the **Conjugatæ**, consisting of the *Zygnemaceæ*, *Mesocarpeæ*, and *Desmidieæ*, a well-marked and sharply differentiated group with no near affinities. It seems to me most probable that the first two families, consisting entirely of unbranched filamentous forms, are derived from the Confervoideæ directly, though the change in the mode of reproduction is very abrupt. The formation of zoospores is entirely suppressed, the only mode of reproduction being lateral conjugation between cells of the same, or scalariform conjugation between those of different individuals. The Desmidieæ must, then, be regarded as a family adapted, by a certain amount of retrogression in both vegetative and reproductive characters, to life in shallow water. If this view be correct, they must be derived, through such filamentous genera as Desmidium and Hyalotheca, from Zygnemaceæ with lateral conjugation. The possible relation of the Diatoms to the Desmids I have already discussed. I believe it to be apparent rather than real. The mode of reproduction by conjugation attains its climax in the Mesocarpeæ, which are distinguished from the Zygnemaceæ mainly by the more complex mode in which the zygosperm is formed.

The second line of descent is that of the Brown Seaweeds. The formation of some coloured pigment to mask the chlorophyll would appear to be a necessary condition of life for the greater part of the inhabitants of deep seas, and indeed of salt water generally. In the huge group of **Phæosporeæ** we have every grade of transition from isogamous to heterogamous reproduction; and, if the principle of classification based solely on the mode of reproduction were consistently carried out, a part of this obviously natural group must be placed in the Zygophyceæ, a part in the Oophyceæ, with other forms intermediate between the two; and in some cases even members of the same family would be separated. The typical Phæosporeæ, such as Punctaria and Sporochnus, are characterized by the possession of two kinds of zoosporange, unilocular and multilocular. The zoospores produced in the two kinds of sporange present no difference in size or form; but those from the unilocular sporanges appear in all cases to germinate directly, while those from the multilocular sporanges are sometimes zoogametes with sexual functions. In some families one or other kind of zoosporange is altogether suppressed; thus the Laminariaceæ * have the unilocular kind only. In the *Ectocarpaceæ* and a few other genera scattered through different families, we have a mode of reproduction closely resembling that in the isogamous Confervoideæ, except in the greater differentiation of the zoosporanges—a conjugation of zoogametes (from the multilocular sporanges) which are to all appearance exactly alike, though a slight differentiation is exhibited in the fact of one of them coming to rest and partially losing its cilia before conjugation takes place. In the *Cutleriaceæ* the differentiation is more complete; the male and female swarm-cells are produced either on the same or on different individuals; the latter are much larger than the former, and come perfectly to rest, entirely losing their cilia before being impregnated by the former. In the *Dictyoteæ*, finally, the differentiation is carried still further, and the female reproductive bodies are, from the first, motionless masses of protoplasm not provided with cilia (oospheres). The Dictyoteæ are further distinguished from the other Phæosporeæ in the non-motile character of both the male and the non-sexual reproductive elements; and in these respects they present a singular identity of structure with the Florideæ. In Dictyosiphon a different mode of reproduction has been observed, somewhat resembling the conjugation of the Conjugatæ.

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* Gardiner believes, however, that he has detected a true sexual reproduction in Alaria.

Various families of Phæosporeæ exhibit reduction or degradation of the vegetative structure. Considerable obscurity rests on the position of the small group named by Rostafinski *Syngeneticæ*; but I am disposed to agree with Hansgirg * in regarding it as having descended by retrogression from the Phæosporeæ. The two genera of which it is composed resemble one another in but few points except the possession of a brown endochrome, and have probably but slight affinity with one another. Hydrurus is a unicellular freshwater organism in which the reproductive bodies are reduced to non-ciliated masses of brown protoplasm which germinate directly without impregnation; in Chromophyton, which is endophytic in Sphagnum, the vegetative structure is almost entirely suppressed, and the reproductive bodies are uniciliated masses of protoplasm of two kinds, but without any observed process of conjugation. Heckel and Chareyre † regard the Diatomaceæ, Syngeneticæ, and Phæosporeæ as successive members of an ascending series.

The step from the Dictyoteæ to the **Fucaceæ** is an easy one. In the highest type of brown seaweeds, such as Fucus or Durvillæa, with their typical heterogamous or "oogamous" reproduction, consisting of the impregnation of a comparatively large oosphere by a number of minute antherozoids, we have the climax of this line of evolution.

The third line of descent from the isogamous Confervoideæ is a much more direct one, viz. to the **Confervoideæ heterogamæ**, consisting of the three families *Sphæropleaceæ*, *Œdogoniaceæ*, and *Coleochætaceæ*. In the first of these, which comprises only a single species, we have a distinct differentiation of the male and female reproductive elements, the latter having now become permanently quiescent, but still a strong reminiscence of the Confervaceæ in the unbranched filament and the multinucleated cells. The Œdogoniaceæ exhibit a distinct advance in vegetative structure, and still more in the cells which contain the male and female reproductive bodies being, for the first time in this series, differentiated into antherids and oogones respectively. In the purely sexual system of classification these two families are placed among the Oophyceæ, while the most highly developed of the three, the Coleochætaceæ, commences the series of Carpophyceæ.

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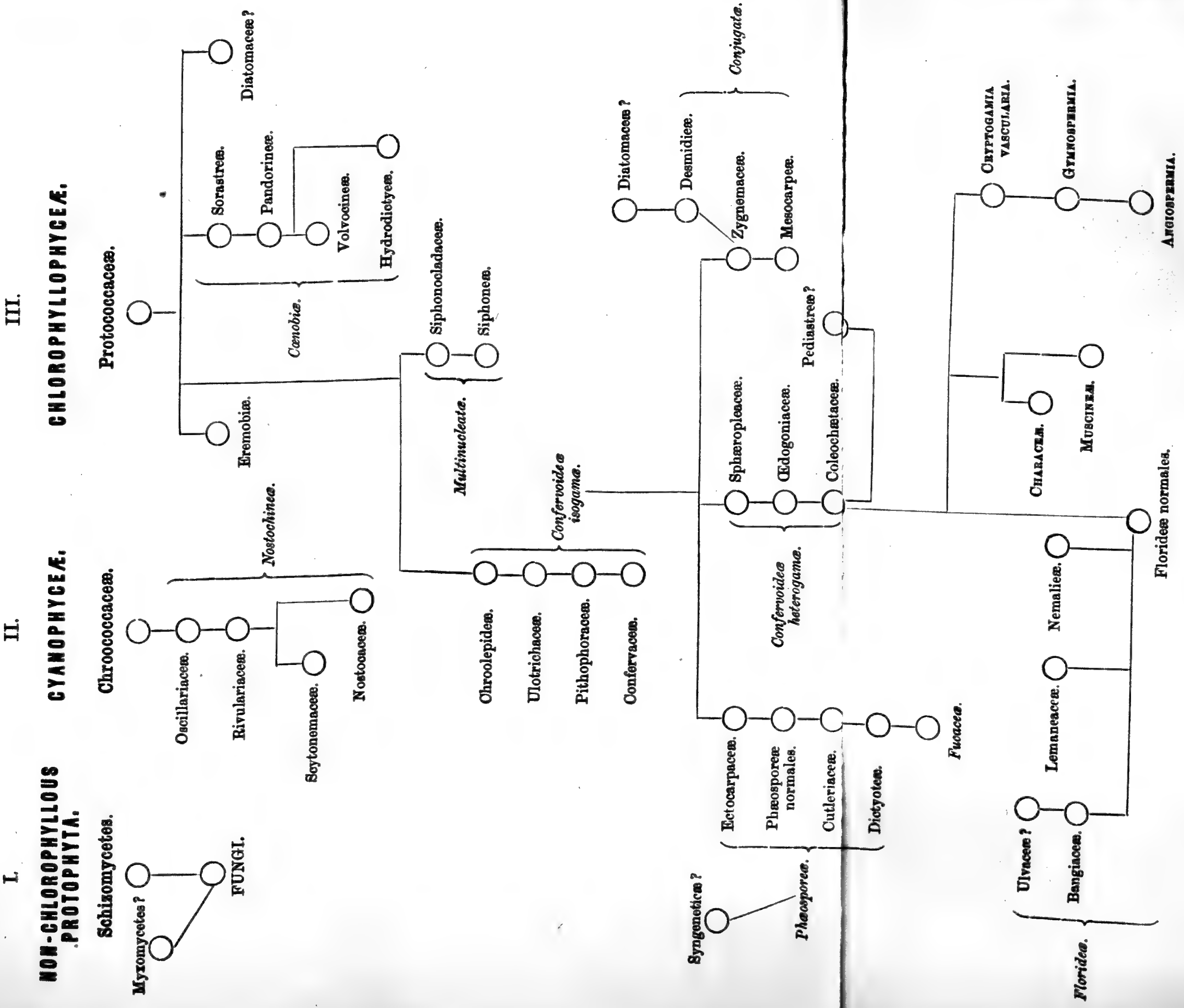
* 'Prodromus der Algenflora von Böhmen.'

† 'Journal de Micrographie,' 1885.

In this family there is still no great advance in vegetative structure, and we have an evident connecting link with Œdogonium in Bulbochæte. In the typical genus Coleochæte we find, in the non-reproductive part of the thallus, a singular change from a filament to a simple plate of cells, adapting it to its mode of growth, as a flat disk attached to the surface of water-plants. The mode of sexual reproduction has, however, attained a much higher degree of complexity. The oogone is surmounted by a tubular appendage, the trichogyne, through which the motile antherozoids find their way to the oosphere in order to impregnate it. The fertilized oogone then becomes invested by a cortical layer of cells, forming the complex body known as the sporocarp. The microscopic family of *Pediastreæ* so closely resembles the Coleochætaceæ in some points, and is so difficult to locate elsewhere, that I find it hardly possible to regard it in any other light than as a degraded type of this family in which every trace of sexual reproduction has been lost. Many authorities place Pediastrum among the Protococcaceæ, others associate it with Hydrodictyon; with the latter genus it seems to me to have scarcely anything in common; in no true sense of the word do its cells constitute a cœnobe.

The Coleochætaceæ lead us up directly to the highest type of structure attained by Thallophytes, the **Red Seaweeds or Florideæ**, a well-defined and natural group, though exhibiting remarkable variety in the degree of development of the sexual organs. So striking is the resemblance in the mode of impregnation in the most highly developed genera of Florideæ, such as Callithamnion, Dudresnaya, or Corallina, to that in Coleochæte, that it is scarcely possible to doubt the direct descent of one from the other. In addition to the acquisition of a red pigment, the chief difference consists in the replacement of motile antherozoids by motionless, or at least not actively motile, male elements known as "spermatia." The process of fertilization is the most complex which occurs among Thallophytes, and presents a remarkable forecast, so to speak, of the mode afterwards elaborated in Flowering Plants, but only after a very long interval comprising the entire evolution of Muscineæ and Vascular Cryptogams. It is instructive to note that with the loss of motility of the male reproductive bodies is correlated the loss of motility also of the non-sexual reproductive bodies or tetraspores. Another possible line of descent of the Florideæ has already been indicated, from the


I.
NON-CHLOROPHYLLOUS PROTOPHYTA.
Schizomycetes.
Myxomycetes?
FUNGI.
II.
CYANOPHYCEÆ.
Chroococcaceæ.
Oscillariaceæ.
Rivulariaceæ.
Scytonemaceæ.
Nostocaceæ.
Nostochineæ.
III.
CHLOROPHYLLOPHYCEÆ.
Protococcaceæ.
Diatomaceæ?
Sorastreæ.
Pandorineæ.
Volvocineæ.
Hydrodictyeæ.
Cœnobiæ.
Eremobiæ.
Siphonocladaceæ.
Siphoneæ.
Multinucleatæ.
Confervoideæ isogamæ.
Chroolepideæ.
Ulotrichaceæ.
Pithophoraceæ.
Confervaceæ.
Diatomaceæ?
Desmidieæ.
Zygnemaceæ.
Mesocarpeæ.
Conjugatæ.
Pediastreæ?
Sphæropleaceæ.
Œdogoniaceæ.
Coleochætaceæ.
Confervoideæ heterogamæ.
Ectocarpaceæ.
Phæosporeæ normales.
Cutleriaceæ.
Dictyoteæ.
Fucaceæ.
Phæosporeæ.
Syngeneticæ?
CRYPTOGAMIA VASCULARIA.
GYMNOSPERMIA.
ANGIOSPERMIA.
CHARACEÆ.
MUSCINEÆ.
Florideæ normales.
Nemalieæ.
Lemaneaceæ.
Ulvaceæ?
Bangiaceæ.
Florideæ.

is obscure; but they must probably be regarded as descended, through many removes now lost, from the Coleochætaceæ. The Muscineæ are regarded by Goebel as probably derivatives from the Characeæ; and this seems the most likely hypothesis; though a difficulty is presented in the relationship of the Hepaticæ, especially the thalloid forms, to the more highly developed Musci, unless the former are regarded as a retrogressive offshoot from the latter. Another possible line of descent of the Muscineæ has been indicated, from Lemanea or similar forms.

Another great gap, in which many connecting links must have been lost, occurs between the Muscineæ and the Vascular Cryptogams. It is difficult to regard the Vascular Cryptogams as descended directly either from the Characeæ or from the Muscineæ. The construction of the vegetative apparatus in the Equisetaceæ among the former reminds one, to a certain extent, of that in the Characeæ. In its general features the mode of sexual reproduction has now become established, to undergo, in Flowering Plants, one more change, in the substitution of motionless pollen-grains with their pollen-tubes for motile antherozoids. From the Selaginellaceæ among Heterosporous Vascular Cryptogams, it is comparatively plain sailing, through the Gymnosperms, to the Angiosperms.

Phæosporeæ through the Dictyoteæ, which agree with the Florideæ in the absence of spontaneous motility in both the sexual and non-sexual reproductive elements. But it seems improbable that modes of reproduction so closely resembling one another as those in the Coleochætaceæ and the Florideæ should have arisen independently. In the higher families of the Florideæ we find also the highest development of the organs of assimilation and conduction among Thallophytes. If the more complicated types of Florideæ are derived by direct descent from the Coleochætaceæ, it follows that the less highly developed families must be regarded as retrogressions from the parent type; and this theory, I venture to think, offers the most probable explanation of the true position of some aberrant forms. In the *Nemalieæ* and *Squamarieæ* the degeneration is exhibited solely in the less perfect development of their thallus, the mode of reproduction being still of the normal character. In the *Lemaneaceæ* this is accompanied also by a simpler structure of the sexual organs. But here, as well as in Batrachospermum, we have the first rudimentary appearance (except among Fungi) of the phenomenon known as "alternation of generations," which attained its acme in the Vascular Cryptogams, and which may possibly indicate the genesis of the Muscineæ. In the *Bangiaceæ* or Porphyraceæ we have a reduction of the thallus to a simple filament or plate of cells, accompanied by a rudimentary development of both oogones and trichogynes, and a limited reversion to motility in the tetraspores. For reasons stated above, it seems to me that we must regard the Bangiaceæ as exhibiting retrogression from the more complicated Florideæ rather than as the lowest member of an ascending series; and, if this view is adopted, a place will be found for the *Ulvaceæ* as derivatives from the Bangiaceæ by further retrogression, displayed in the entire suppression of oogones and antherids, and reversion to an ealier mode of reproduction—the conjugation of zoogametes. In a purely sexual system of classification the Ulvaceæ must, of course, be placed among the Zygophyceæ; but their vegetative structure differs widely from all the other members of that group, while the affinity of Ulva to Porphyra can scarcely be doubted.

This completes the attempt at tracing the affinities of the various families of Algæ. The Characeæ, though included by some writers under Algæ, are best dissociated from them in consequence of their distinct cormophytic structure. Their genesis

Phytobiological Observations; On the Forms of Seedlings and the Causes to which they are due.—Part II. By Sir JOHN LUBBOCK, Bart., V.P.L.S., F.R.S., M.P., D.C.L., LL.D.

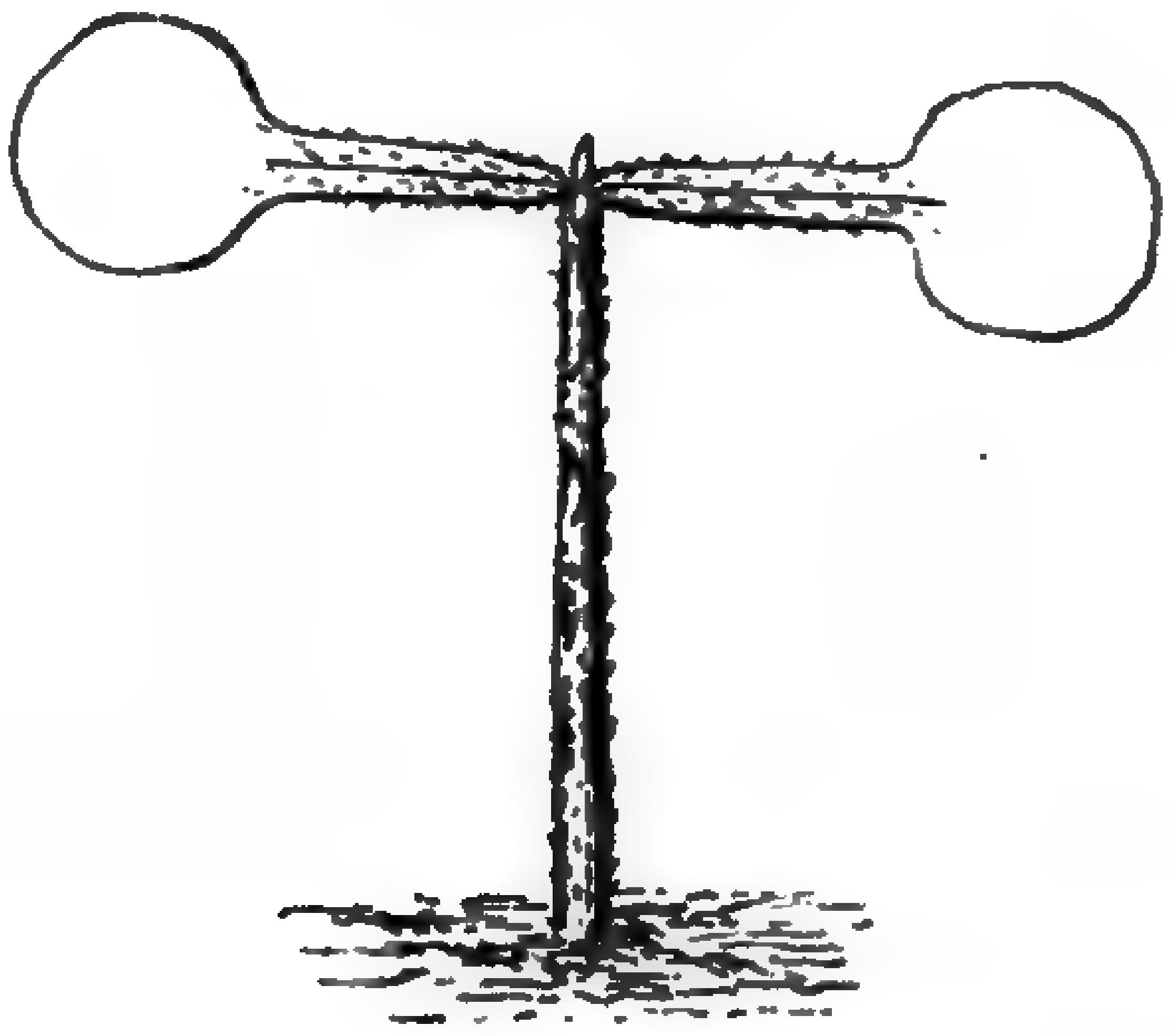
[Read 17th February, 1887.]

INFLUENCE OF THE LEAF ON THE COTYLEDON.

Seedlings of Onagrarieæ.

SOME of the Onagrarieæ have seedlings with very curious cotyledons. For instance, I was greatly puzzled by the seedling of *Œnothera bistorta*, in which (fig. 135) the cotyledons were long and linear, suddenly widening at the end into a large orbicular expansion, which gives them a very peculiar appearance.

Fig. 135.



Seedling of *Œnothera bistorta*. ×3.

In *Eucharidium grandiflorum* (fig. 138) or *Clarkia rhomboidea* (fig. 143) the form of the cotyledon might not unnaturally be supposed to be a case similar to that of *Malva*. In reality, however, the explanation is very different. In *Eucharidium* the lobes have nothing to do with the arrangement of the embryo in the seed. The young plant, indeed, immediately after germination, presents no trace of them. The cotyledons, when they first emerge from the seed (fig. 136), are oblong-orbicular, sessile, cordate or auricled at the base, and emarginate at the apex, with a small purple tooth in the notch; they grow rather rapidly, become shortly petioled, and develop one or two lateral, incurved nerves on each side of the midrib.

In the next stage, about eight days after germination, they exhibit a very slight constriction near the base of the cotyledons, with a small obtuse tooth. This basal portion increases much more rapidly, while the growth of the terminal portion (which is, in fact, the original cotylèdon) becomes gradually arrested. The tooth becomes more marked (fig. 137), and by the tenth day the new portion is obtusely 2-toothed or crenate, and nearly equals the original cotyledon in size.

Fig. 136.

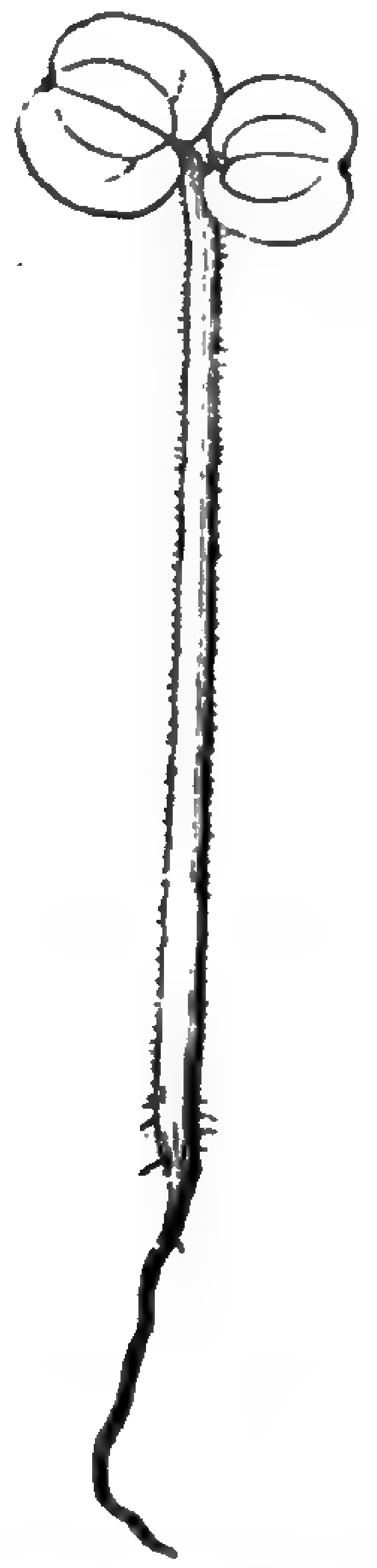


Fig. 137.

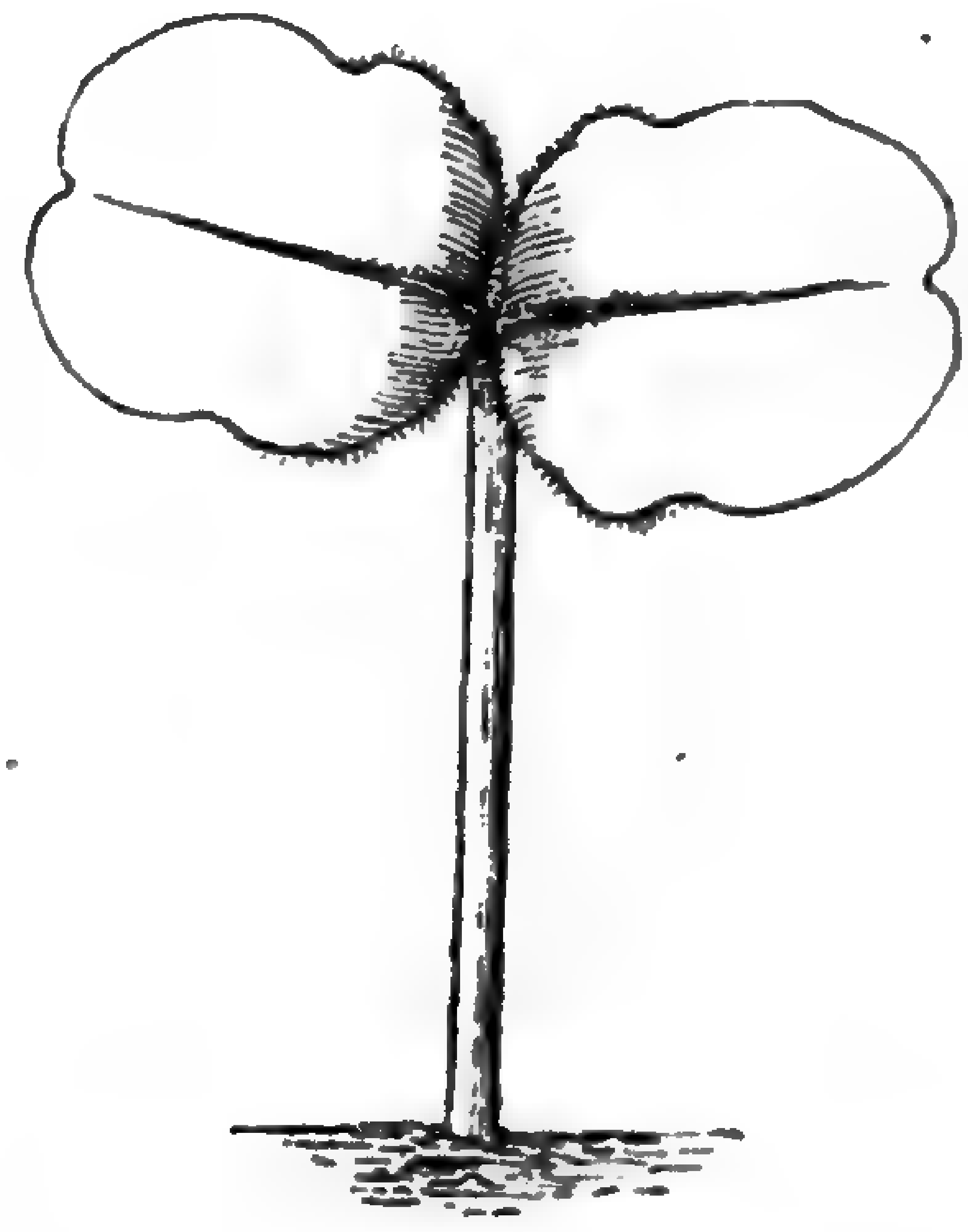


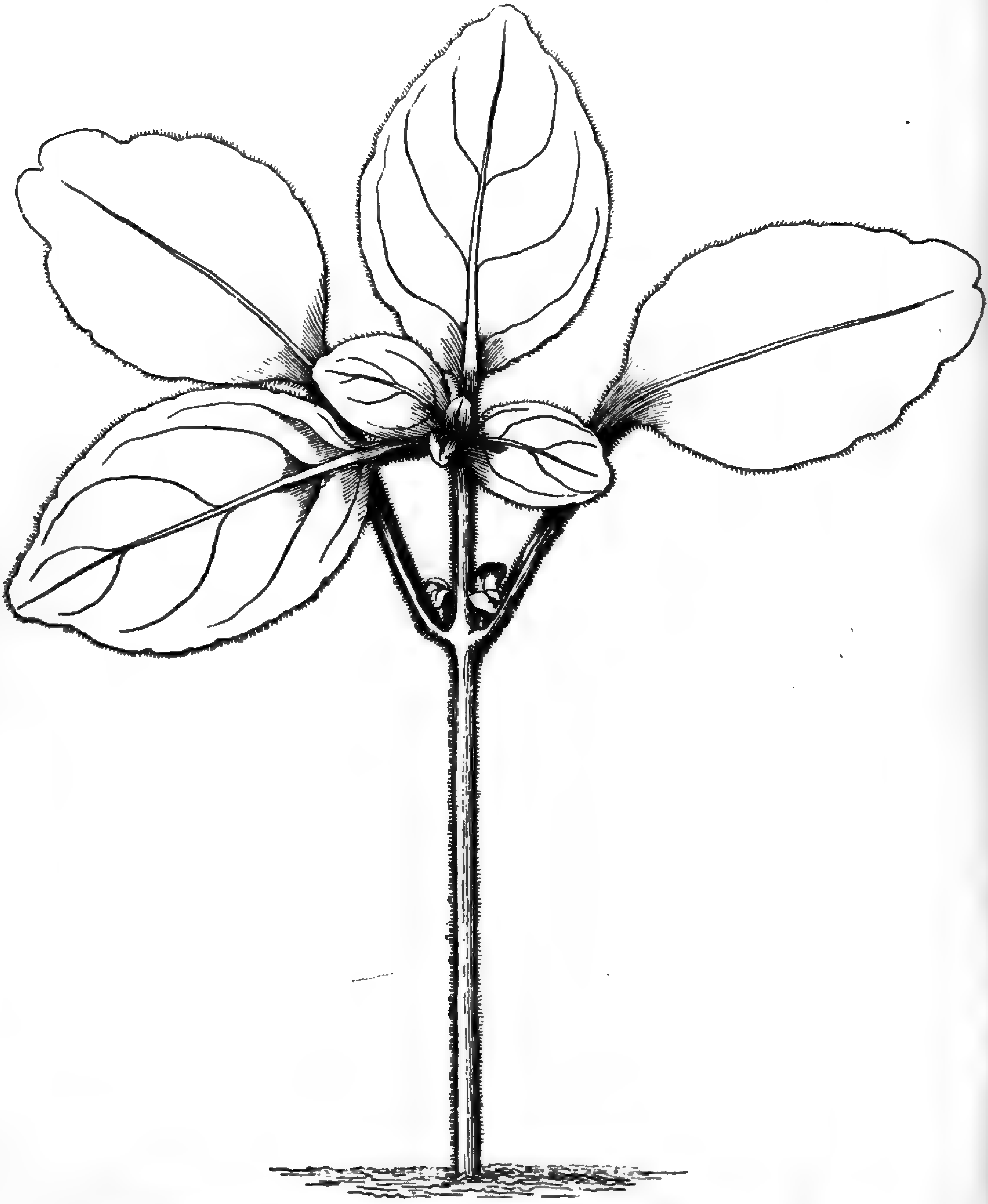
Fig. 136. Seedling of *Eucharidium grandiflorum*. ×3.
Fig. 137. *Eucharidium grandiflorum*: 10 days after germination. ×3.

In its final form (fig. 138) the new portion is both broader and longer than the true cotyledon, and differs from it not only in the crenations, but in the possession of a more conspicuous midrib and rather stiff hairs. Not only is this basal portion interesting in its mode of development, but also from its similarity to the subsequent leaves. In fact, as fig. 138 shows, it may be said that we have a compound structure formed of a leaf at the base, terminated by the cotyledon.

If, indeed, this species stood alone, we might regard the resemblance as accidental; but we find a very similar growth in other allied species.

In *Clarkia pulchella* (fig. 139) the cotyledons immediately after germination closely resemble those of *Eucharidium grandiflorum* (fig. 136). They are oblong-oval, entire, with a slightly prominent colourless tooth at the apex of the midrib, sessile, and very shortly auricled at the base. Six days after germination they are orbicular, shallowly emarginate, very shortly petiolate, and slightly cordate at the base. In a short time they become broadly ovate, emarginate, suddenly narrowed, and rounded at the base. In this case there is no great change

Fig. 138.

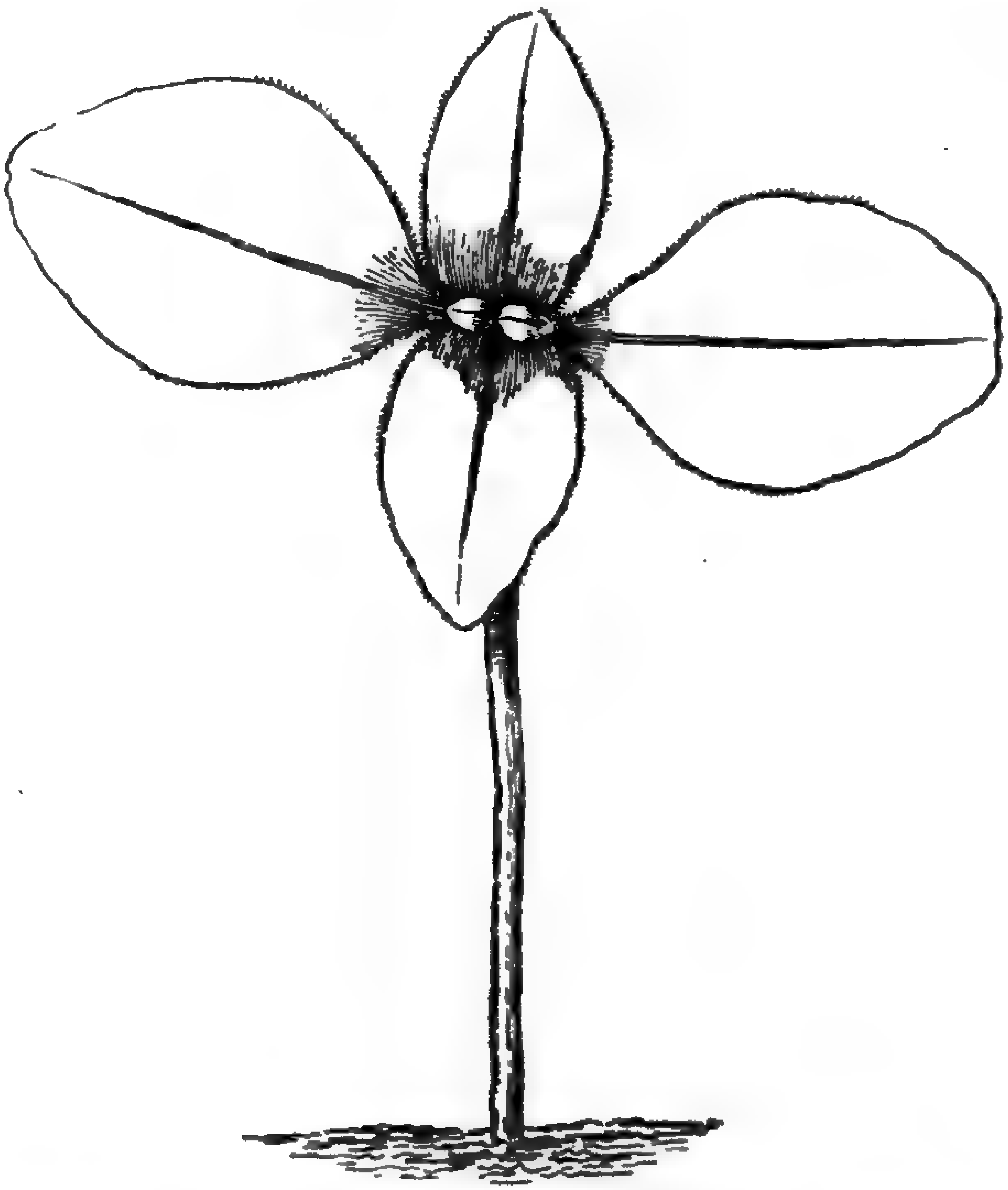


Eucharidium grandiflorum: showing final form of cotyledons. Nat. size.

of form; but while the margin of the original cotyledon is glabrous, that of the new growth and of the true leaves (fig. 139) is finely ciliate.

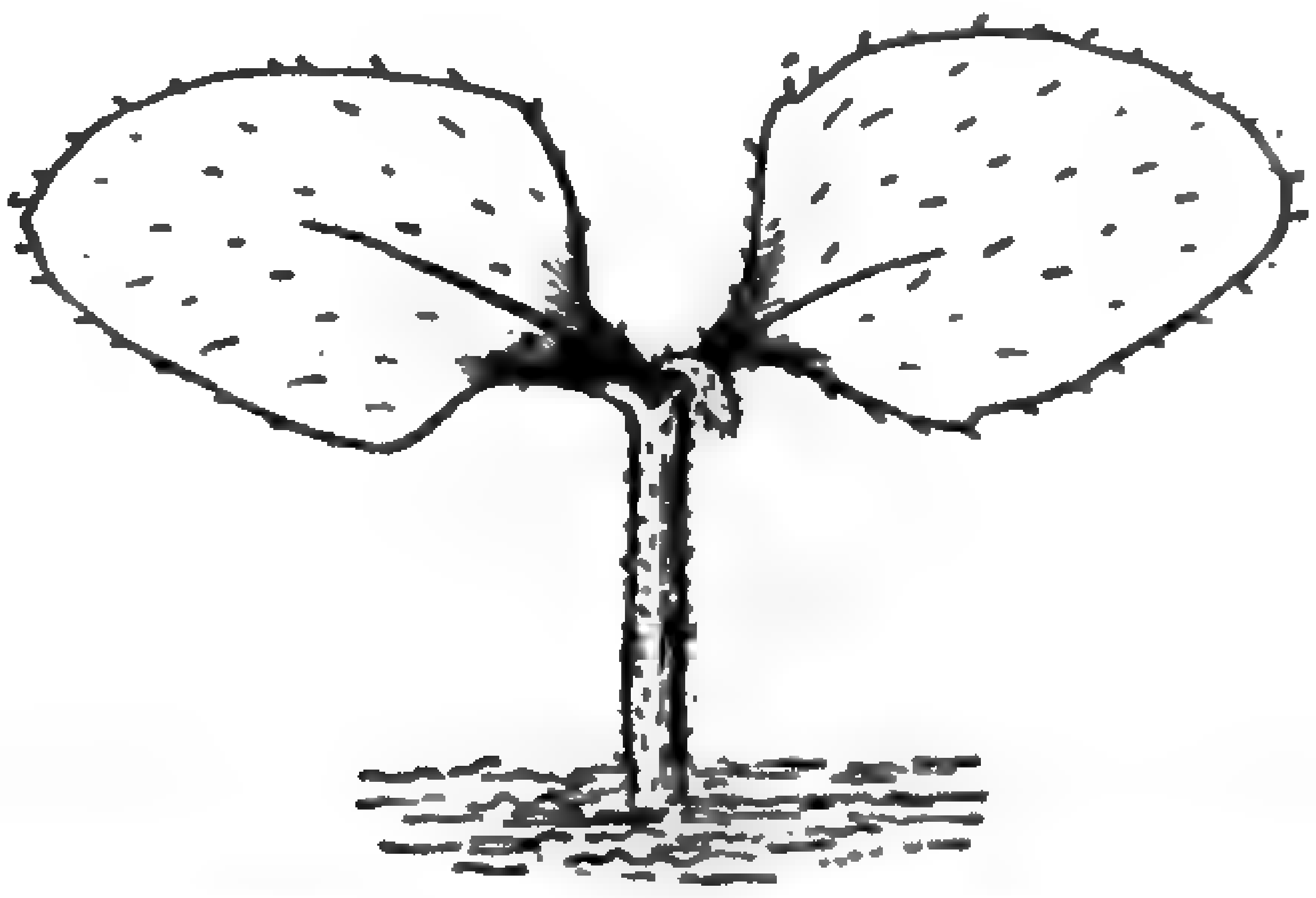
In *Œnothera stricta* the cotyledons immediately after germination are oblong, obtuse, slightly auricled at the base; otherwise entire, sessile, thinly glandular, pubescent on the upper surface, and ciliate. Eight days after germination (fig. 140) they are more distinctly petiolate, ovate, obtuse, cuneate at the base, often subelliptic, sometimes with a minute but distinct tooth below the middle on each side, denoting the line of demarcation between the original portion and the new growth. After this the terminal portion does not alter much; the basal part, on the

Fig. 139.



Clarkia pulchella. Two-thirds nat. size.

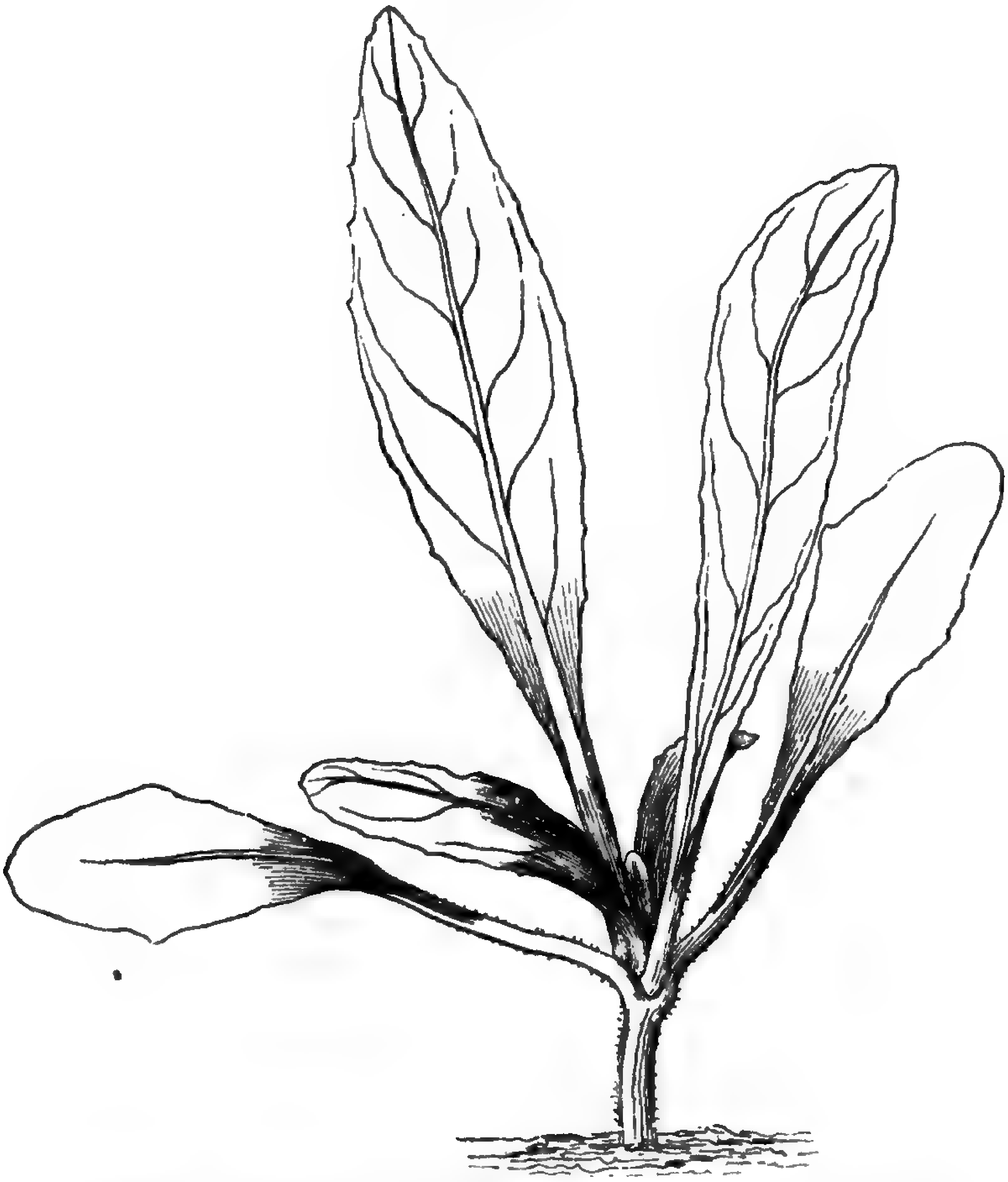
Fig. 140.



Œnothera stricta: 8 days after germination. ×3.

contrary, continues to grow, and eventually (fig. 141) the cotyledons are spatulate, obovate or oblong-obovate, obtuse, with a tooth on each side; the lower part with a distinct midrib and tapering much to the base, glabrous, with puberulous, pubescent petioles, connate at the base.

Fig. 141.



Œnothera stricta: 30 days after germination. Nat. size.

The first leaves are alternate, lanceolate, obtuse, tapering to the petiole, obsoletely and distantly toothed at the margins, and, like the petioles, are glabrous with pubescent petioles.

In *Clarkia rhomboidea* the cotyledons immediately after germination are orbicular, entire, or very faintly emarginate, with a more or less prominent apical tooth, sessile, glabrous, and purplish. One day after germination they are rather more distinctly emarginate and minutely papillosely pubescent. After a week more they are (fig. 142) obovate or subpanduriform, emarginate, with a small tooth in the notch, constricted below the middle. The basal portion is much more conspicuously pubescent, and has a pale pink or purplish midrib, ending in a broader purple patch at the base of the terminal portion.

After this stage the apical portion alters but little. The basal portion, on the contrary, continues to grow; so that, a month after germination, the cotyledons (fig. 143) are oblong, distinctly petiolate, constricted at the union between the original cotyledon and secondary growth, emarginate with a minute tooth in the notch, cuneate at the base, with a distinct midrib throughout, and a few indistinct alternate nerves on each side.

Fig. 143.

Fig. 142.

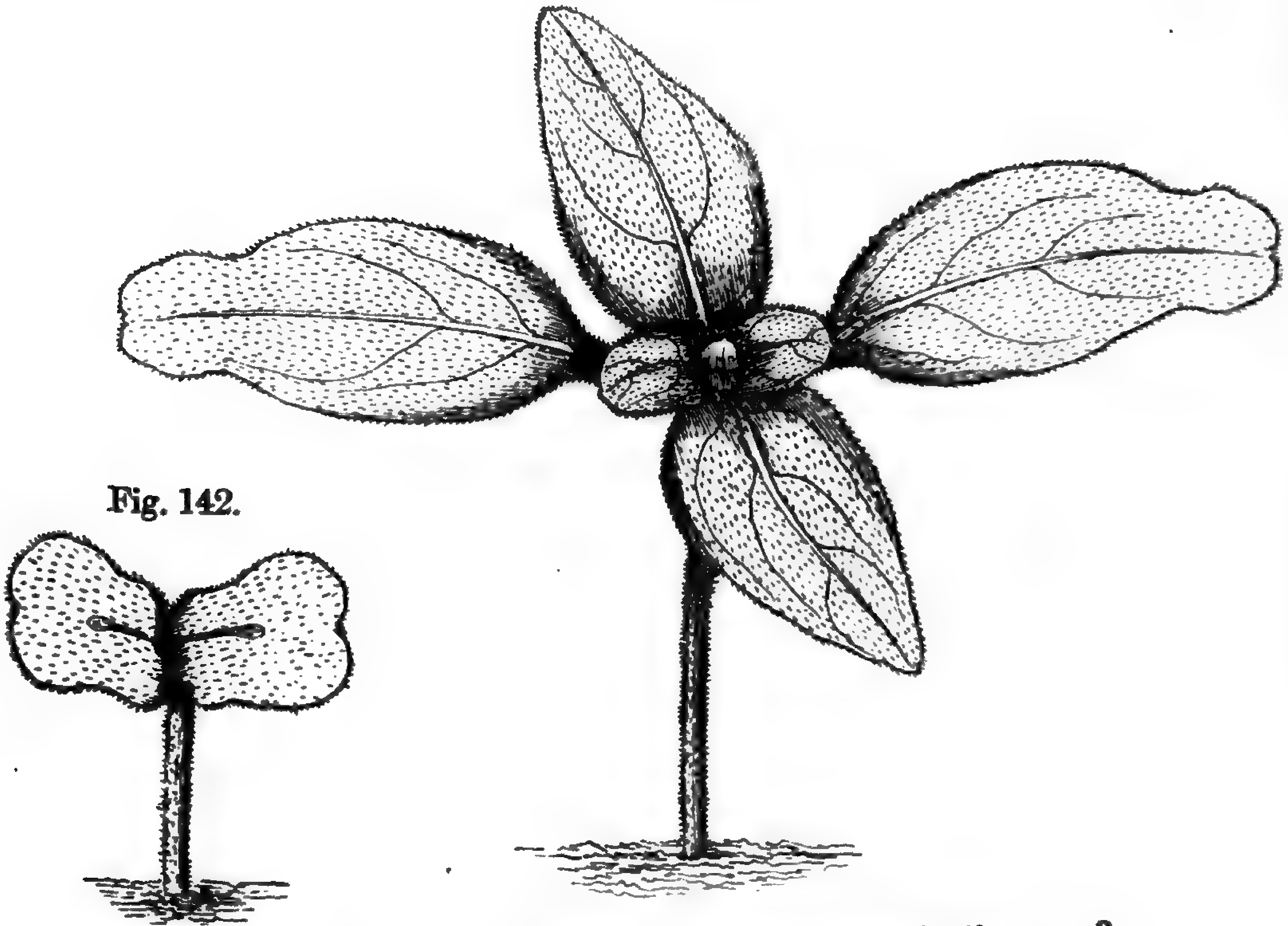


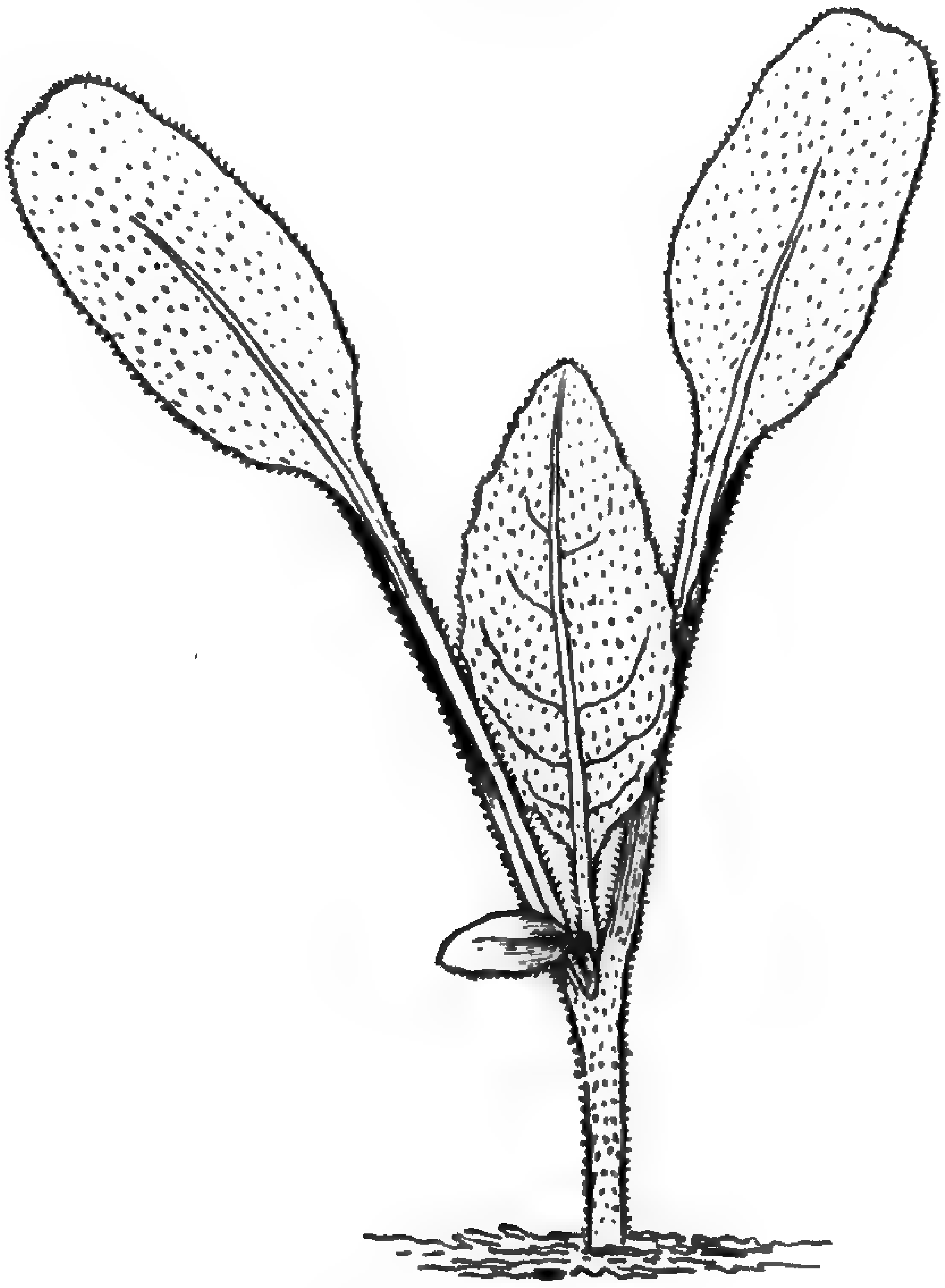
Fig. 142. *Clarkia rhomboidea*: 8 days after germination. ×3.
Fig. 143. Ditto: 30 days after germination. Nat. size.

The first pair of leaves are opposite, ovate, obtuse, cuneate at the base, alternately incurvinerved, entire, shortly petiolate, and densely pubescent.

In *Œnothera taraxacifolia* the cotyledons are at first oblong, obtuse, entire, sessile, and with glandular pubescence on the upper surface. They grow rapidly, and one day after germination they are much larger and petiolate, but otherwise unaltered. They gradually (fig. 144) become emarginate, and grow more in length than in breadth. The petioles also elongate considerably.

The first leaves are alternate, lanceolate, obtuse, petiolate, alternately nerved on the upper half, and oppositely nerved on the basal half, obtusely and obsoletely dentate at the margin, and glandular pubescent. Here, again, the foliar portion of the cotyledon resembles the true leaf.

Fig. 144.



Œnothera taraxacifolia: 16 days after germination. Nat. size.

In *Clarkia gaurioides* the cotyledons immediately after germination (fig. 145) are oblong-orbicular, emarginate, with a small tooth in the notch, slightly auricled at the base, and sessile, with a scarcely discernible midrib. After five days a new growth has taken place at the base (fig. 146), much narrower than the true cotyledon, and with a small tooth on each side. After ten days the new portion is as long as, though narrower than, the true cotyledon, and has 2, 3, or 4 teeth on each side, with a well-marked midrib. Eighteen days after germination the new portion is both longer and broader than the true cotyledon; the whole organ is broadly ovate, cuneate at the base, petiolate, the new portion has 4–6 small obtuse teeth on each side, is broadly subelliptic in outline, and minutely ciliate at the margin. It is remarkable also that the cotyledons have become more or less distinctly alternate. Here it is still more evident, as figs. 147

and 148 show, that the new growth has a distinctly foliar character.

In *Œnothera Lindleyana* and *Œ. amœna* the development is very similar to that of *Clarkia gaurioides*. *Œ. tenella* belongs also to this group.

Fig. 146.

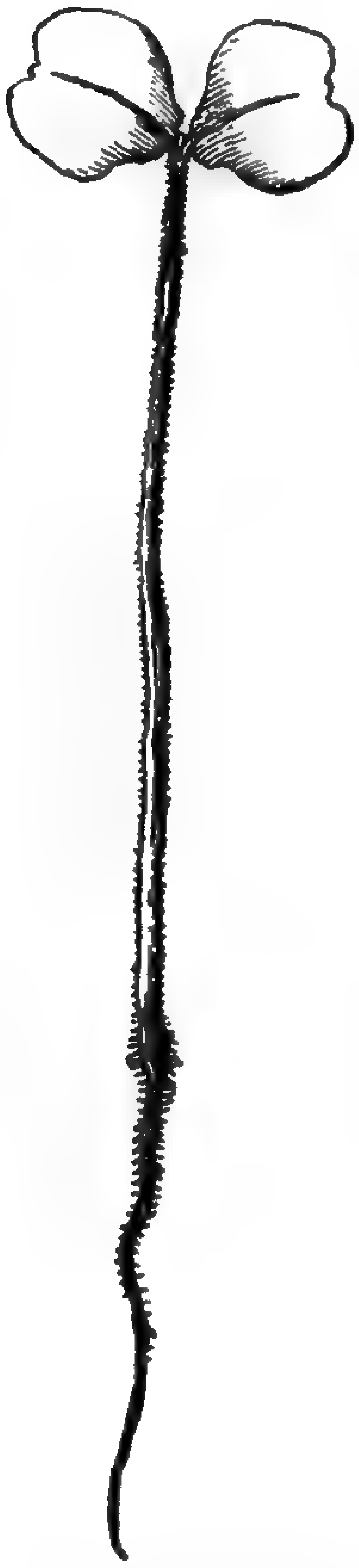


Fig. 145.

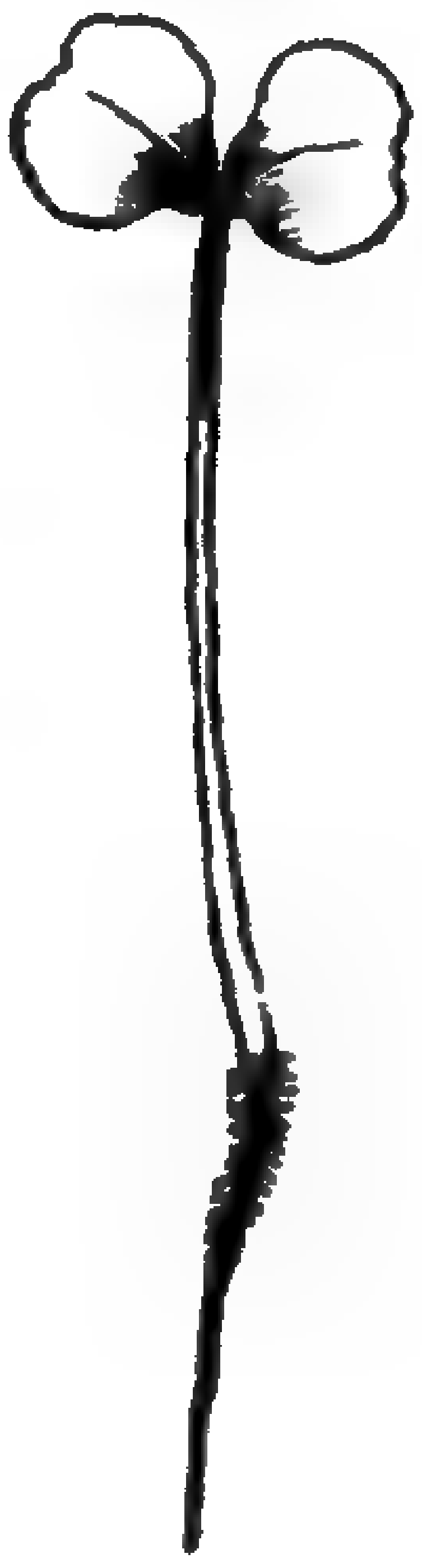


Fig. 147.

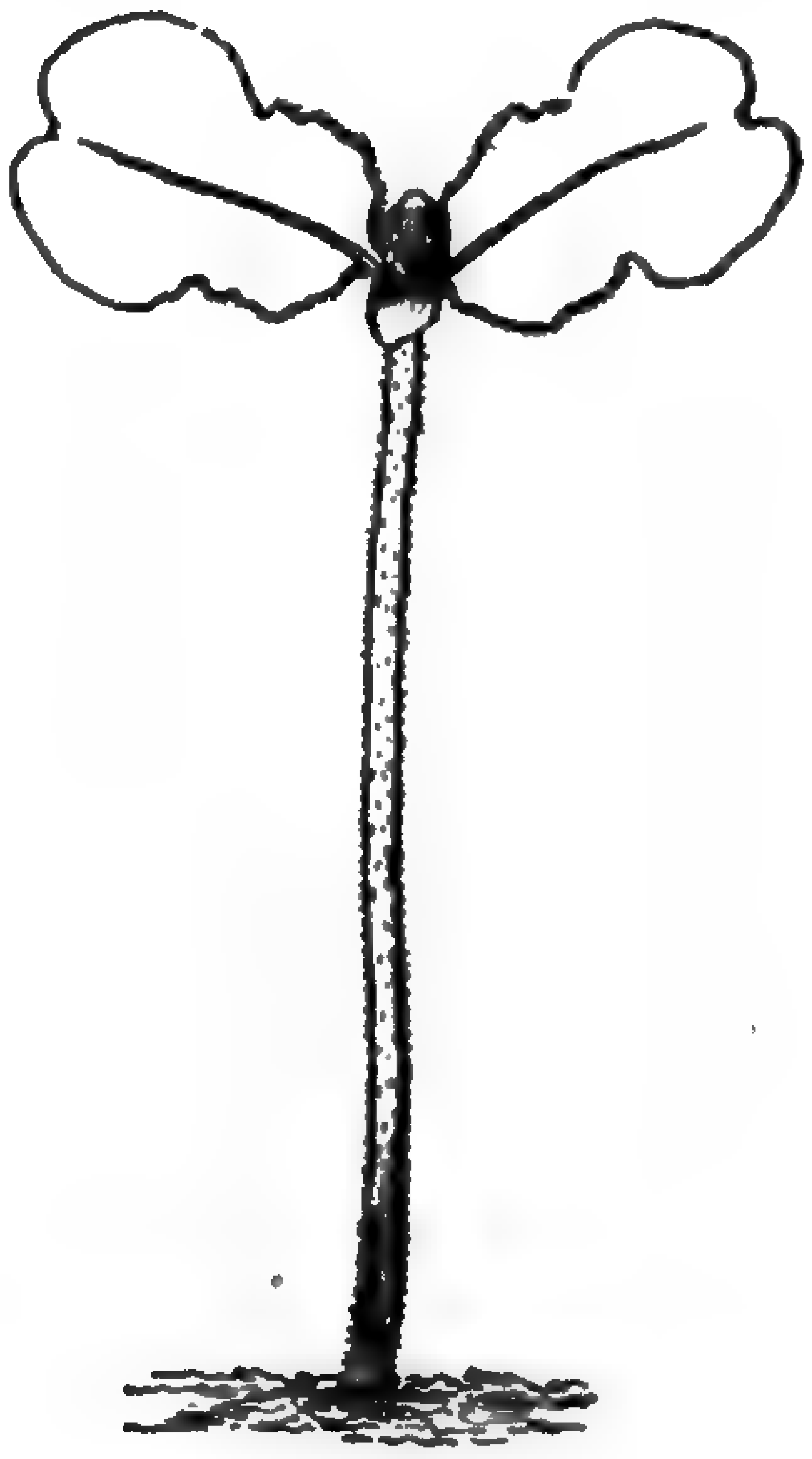
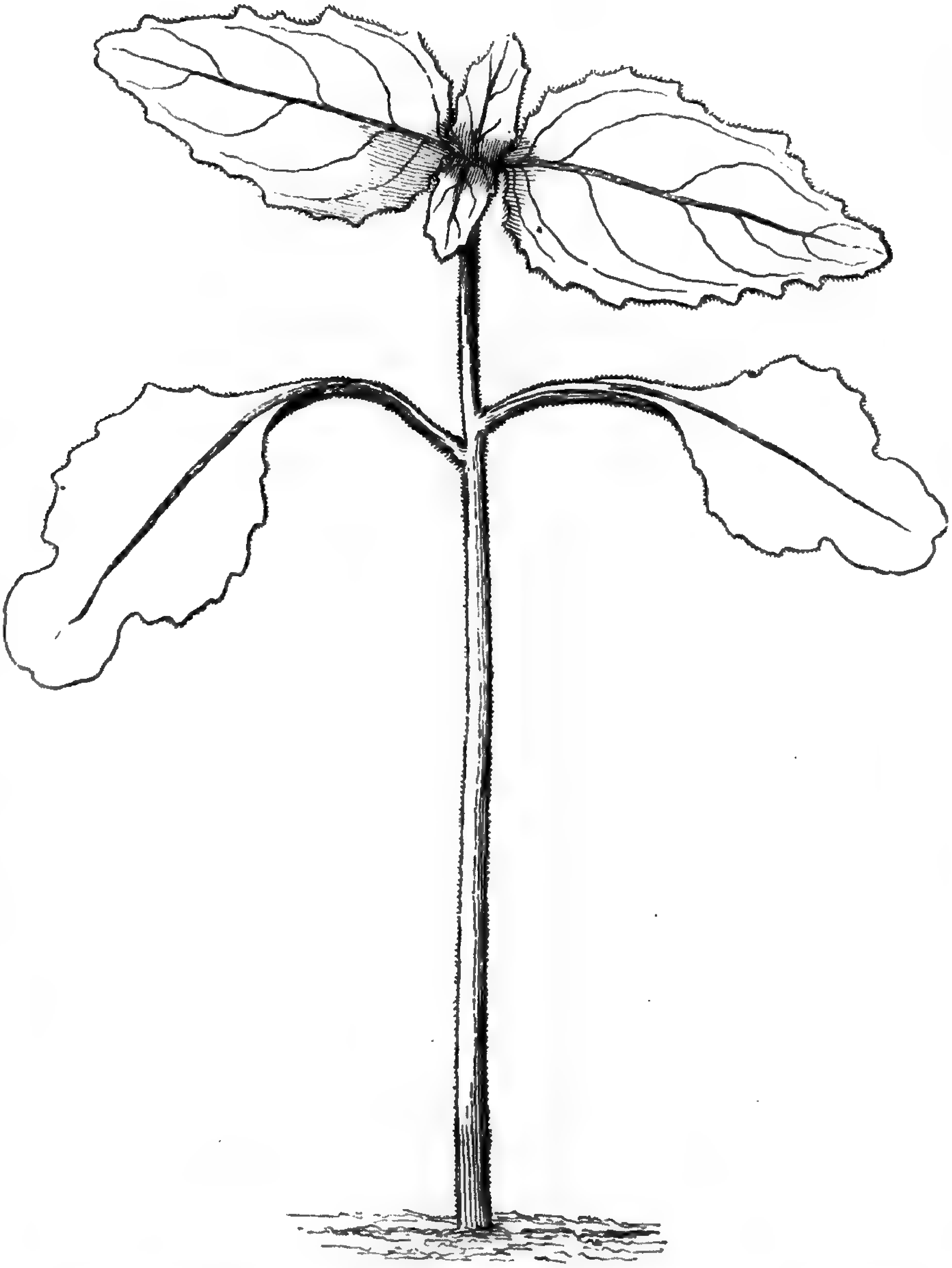


Fig. 145. *Clarkia gaurioides*: seedling. Nat. size.
Fig. 146. Ditto: seedling, 5 days after germination. Nat. size.
Fig. 147. Ditto: seedling, 10 days after germination. Nat. size.

The same is the case with the earlier stages in *Clarkia integripetala*; but in this species, while the original cotyledon is all but glabrous, the foliar portion resembles the leaves in being conspicuously pubescent on the upper surface. The passage from the one portion to the other is abrupt; and, the veins being also well-marked in the foliar part of the cotyledon, the contrast between the two regions is very conspicuous.

In *Eucharidium concinnum* the cotyledons follow a similar course of development; but the upper surface of the original cotyledons are glandular, though less conspicuously so than the foliar portion. The passage also is less abrupt. The foliar portion is larger in proportion, and the margin is crenate but not toothed.

Fig. 148.

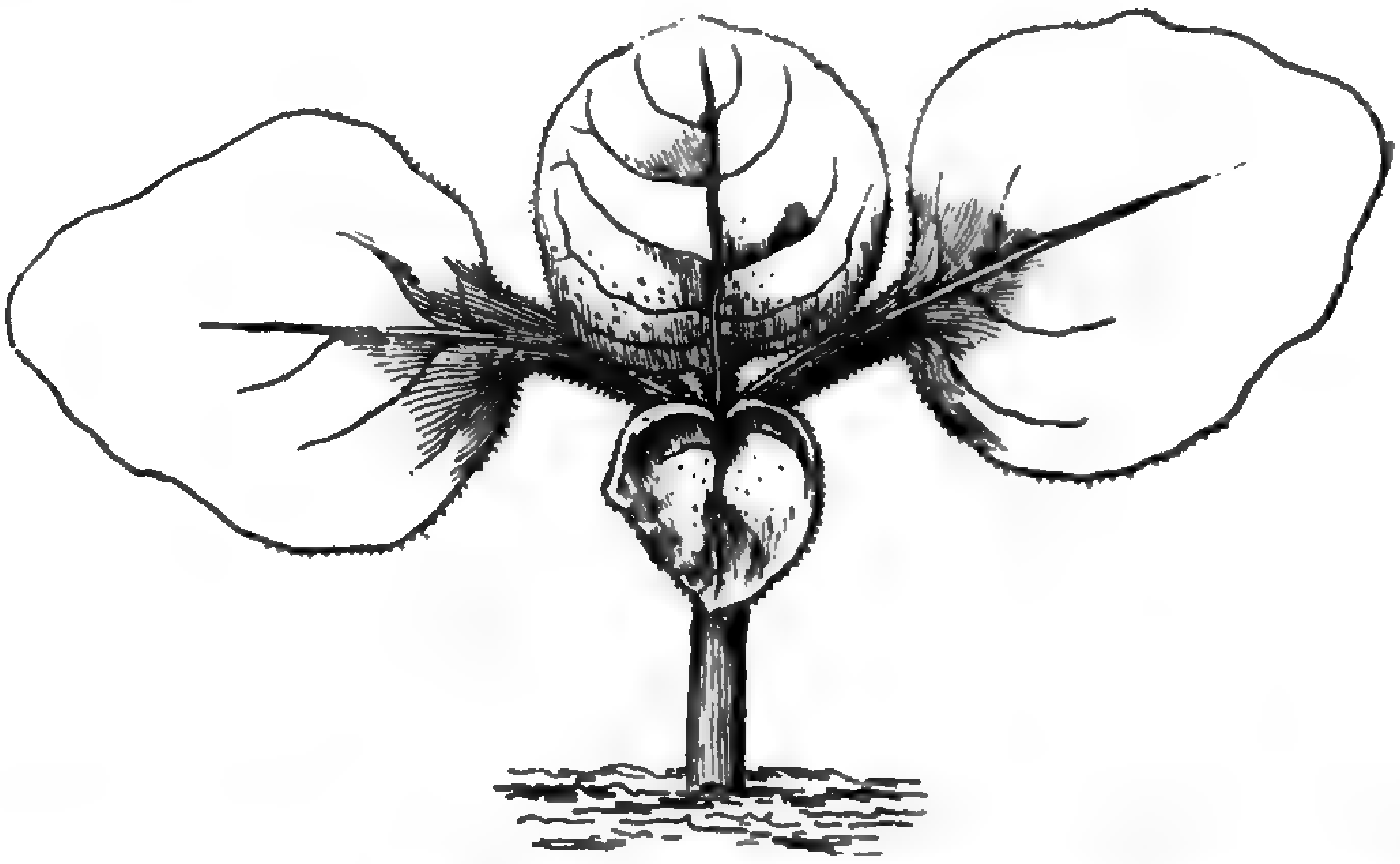


Clarkia gaurioides: seedling, 18 days after germination. Nat. size.

The first two leaves are opposite, oblong-ovate, obtuse, with a distinct midrib, but indistinct lateral nerves, and minutely glandular pubescence all over the upper surface.

Œnothera biennis and *Œ. micrantha* afford a striking contrast. The leaf of the former (fig. 149) is broad, nearly orbicular, finely ciliated at the margin, and the midrib is rather weak, with strong curved lateral branches; that of the latter is (fig. 153), on the contrary, linear-lanceolate, with one or two blunt teeth on each side, with somewhat larger hairs, and a stout midrib without lateral branches.

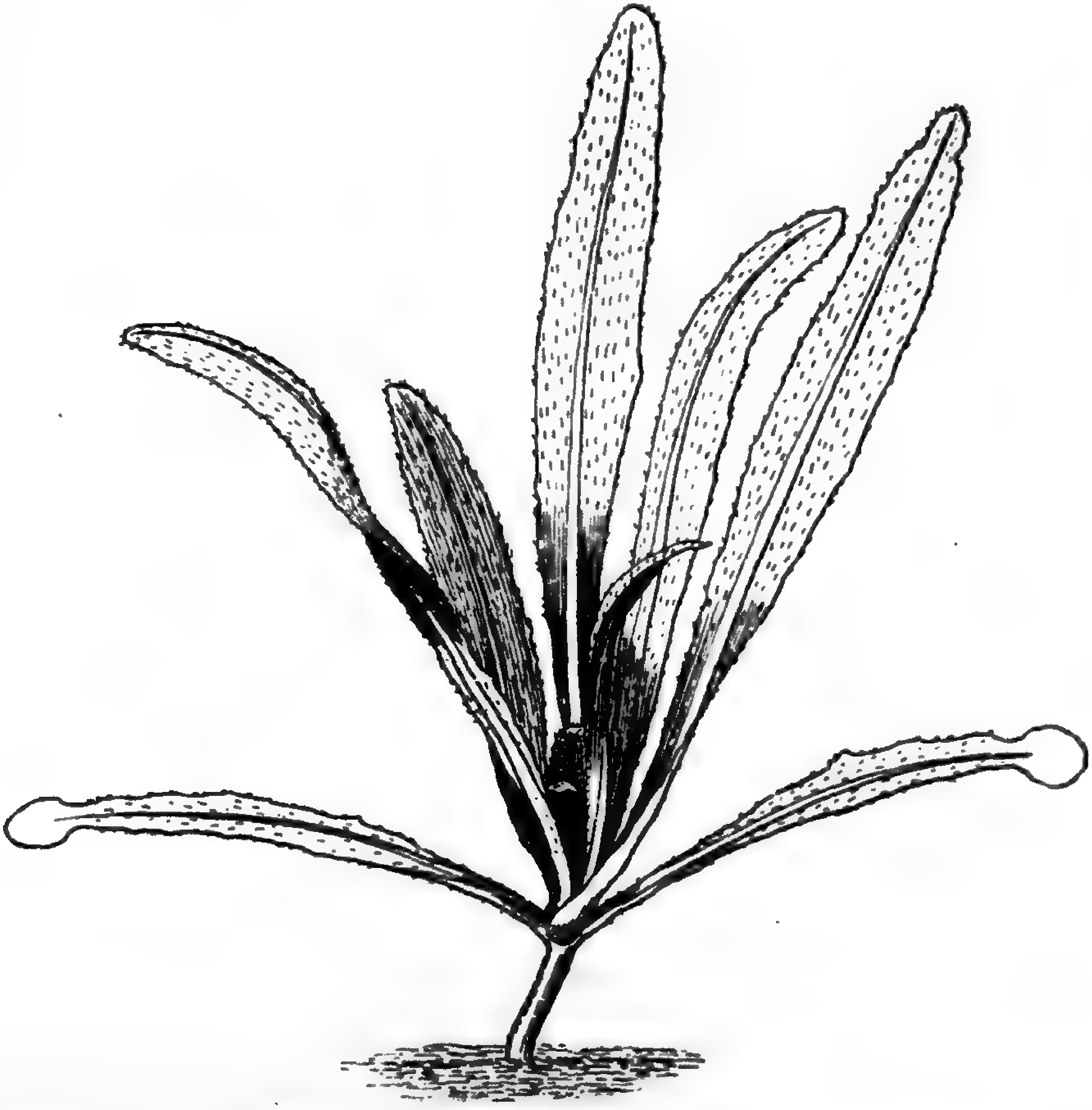
Fig. 149.



Œnothera biennis: seedling, 16 days after germination. Nat. size.

The cotyledons immediately after germination are in both cases (fig. 151) oval, obtuse, and entire, with a slightly prominent

Fig. 150.



Seedling of *Œnothera bistorta*. ×3.

apical tooth, that of *Œ. biennis* being subsessile, that of *Œ. macrantha* very shortly petiolate. In *Œ. biennis* the cotyledons appear simply to expand; they retain the broadly ovate form, with the minute apical tooth, but become gradually petiolate *.

But though there is thus no marked constriction in *Œnothera biennis* between the original cotyledon and the new growth, the latter is marked by a slight tooth at the point of junction, but still more by having the margin ciliate with incurved hairs, and a midrib with curved lateral veins; in both which characters it resembles the true leaf.

In *Œ. Lamarckiana* the cotyledons resemble those of *Œ. biennis*, but become rather more truncate at the base and more pointed at the apex; so that their form is more wedge-like or obcuneate. The apical tooth is not apparent, and the basal foliar portion of the cotyledon is distinguishable only by the midrib and the fringe of incurved hairs, there being neither a notch nor a tooth to mark the transition.

In *Œ. rosea* the cotyledons resemble those of *Œ. biennis*; but they have not the apical tooth, and the margin is not ciliate. In this species, however, the leaves themselves are distantly dentate, and the petioles are slightly pubescent but not hairy at the margin; they are broadly ovate, obtuse, entire, and with petioles nearly equalling their own length.

In *Œnothera linearis* the cotyledons much resemble those of *Œ. rosea*, as also do those of *Œ. pumila*, *Œ. serotina*, and *Œ. glauca*, which latter, however, are ultimately cuneate at the base.

To the same group of species, so far as the cotyledons are concerned, belongs also *Œ. fruticosa*.

Œnothera micrantha affords us a case very similar to *Œ. bistorta*. The cotyledons immediately after germination (fig. 151) are, as already mentioned, oval-obtuse with a slightly prominent apical tooth, and very shortly petiolate; they soon become (fig. 152) spatulate, with an oval entire tip representing the original cotyledon, and a linear cuneate portion at the base, generally with a minute tooth on each side, and glandular pubescence. In the third stage (fig. 153) they are linear, resembling a stout handle to the broad ovate cotyledon, which has grown to about twice its original length and retains the original form. Nineteen days after germination (fig. 154) they become narrowly spatulate, or linear with an oval tip, no wider, or even sometimes rather narrower, than the greatest width of the new portion, which closely resembles the leaf and is linear, somewhat broader in the middle, with two or three obsolete teeth on each side, ciliated at the margins and with a broad midrib.

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* The arrangement of the cotyledons in the seed is variable: sometimes they are flat, sometimes involute.

Fig. 151.

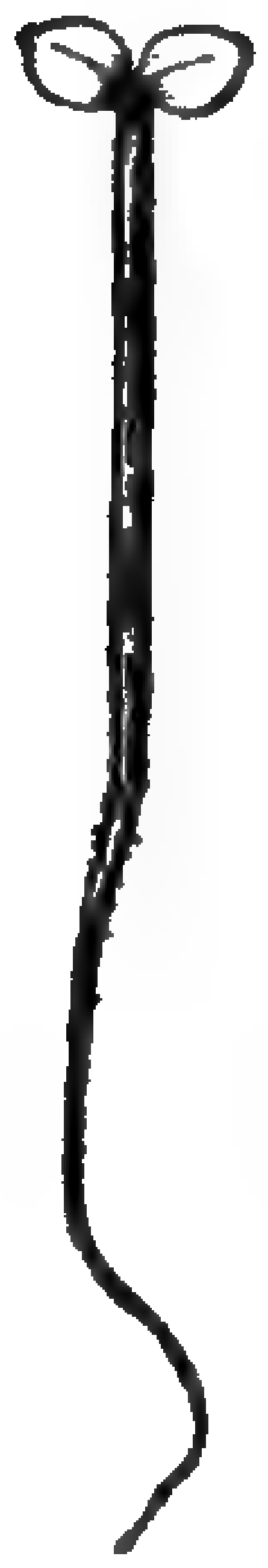


Fig. 152.

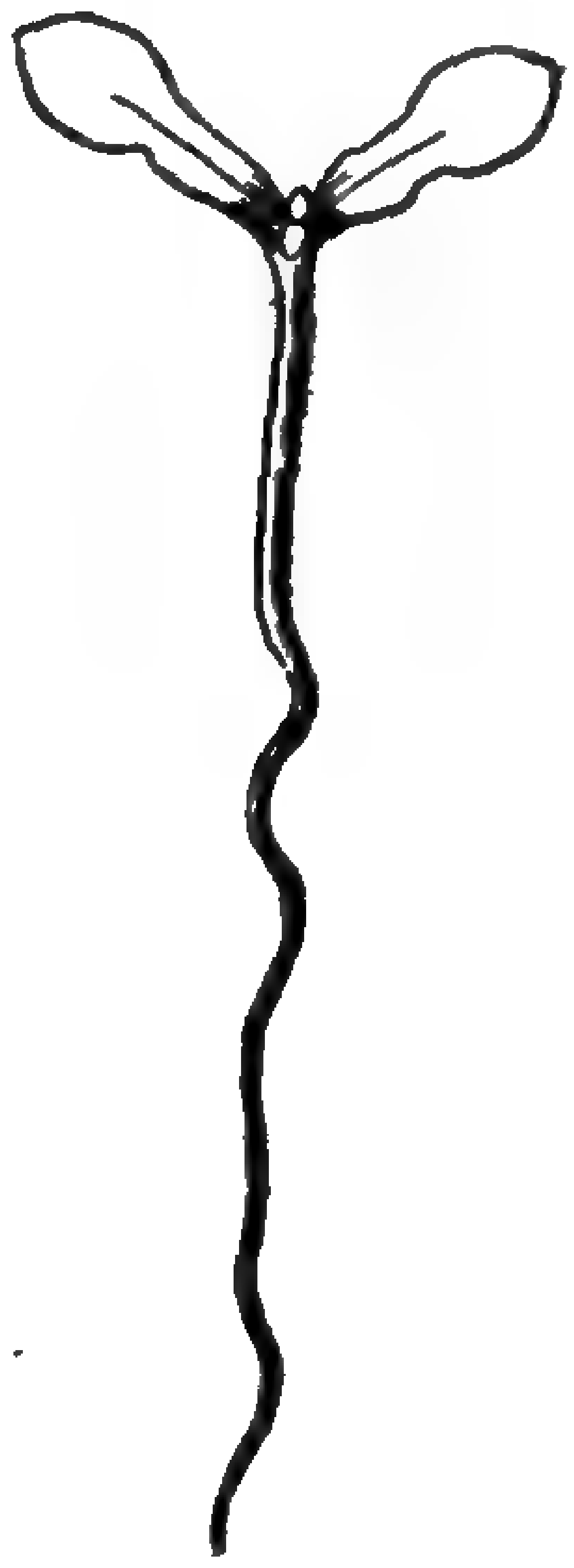


Fig. 153.

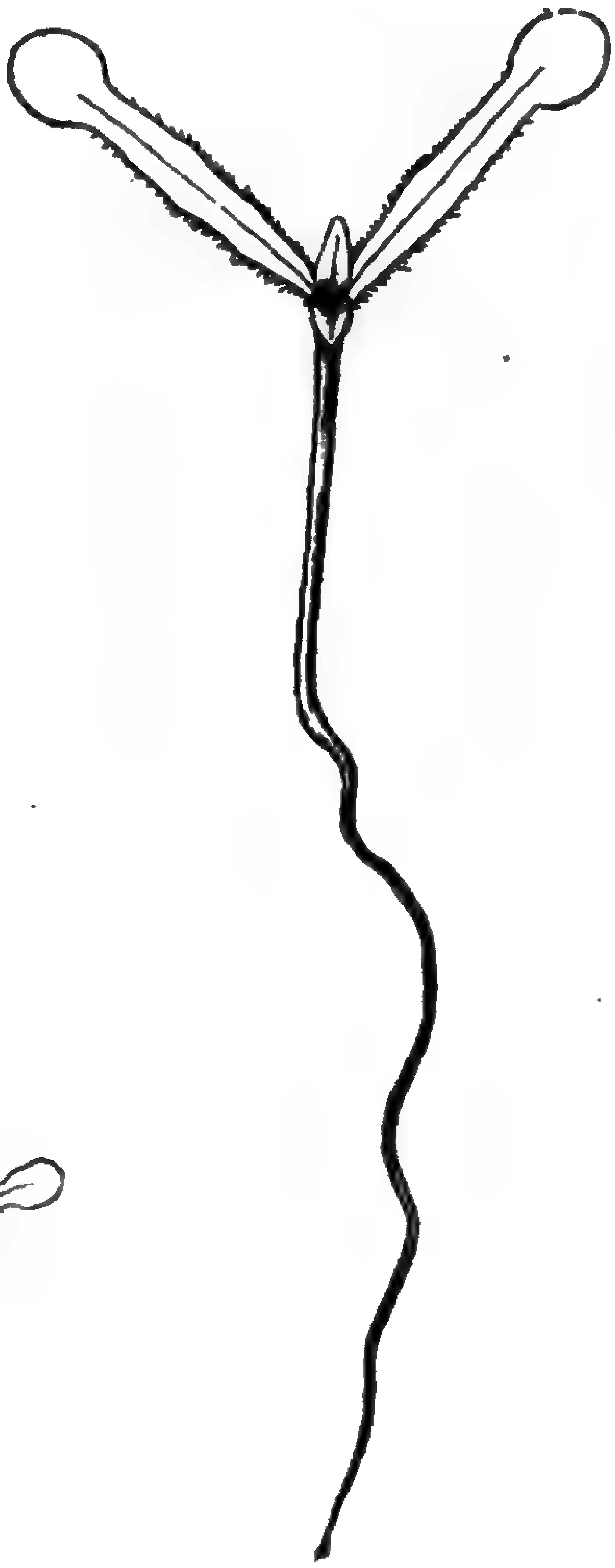


Fig. 154.

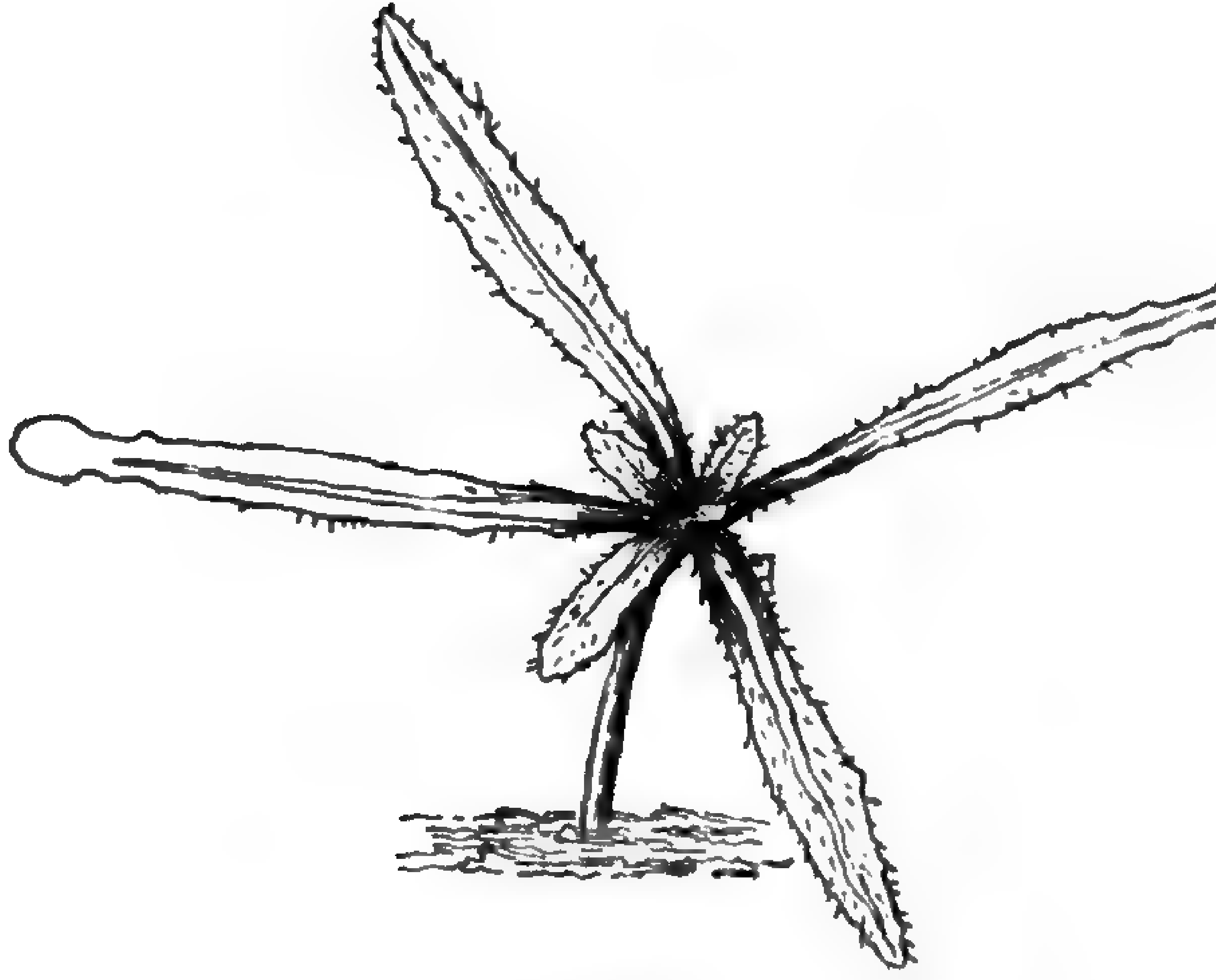
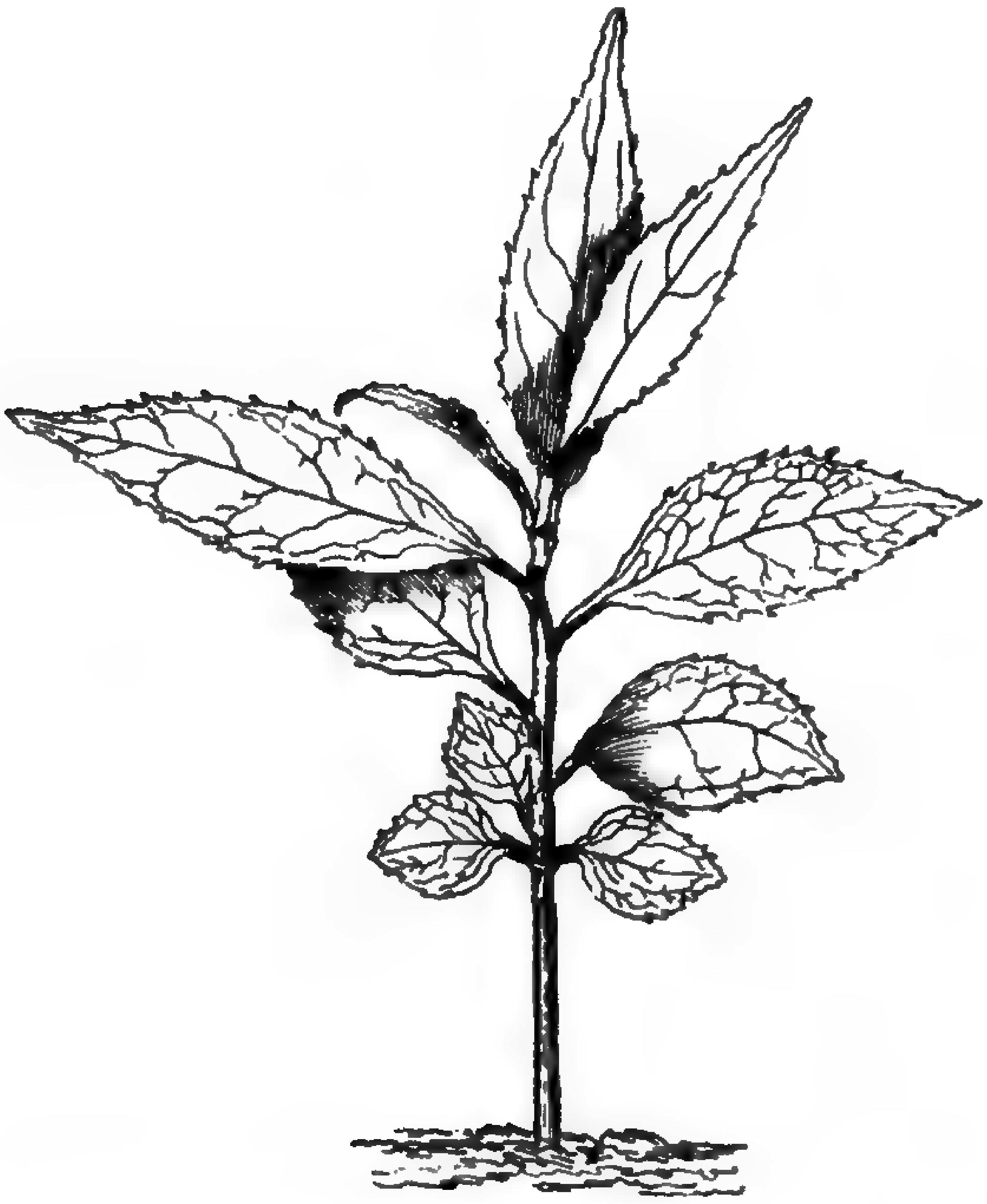


Fig. 151. *Œnothera micrantha*: seedling. ×3.
Fig. 152. Ditto: seedling, 7 days after germination. ×3.
Fig. 153. Ditto: seedling, 9 days after germination. ×3.
Fig. 154. Ditto: seedling, 19 days after germination. Nat. size.

Here, therefore, we have an interesting group in which at first the cotyledons are very similar, but by subsequent growth at the base develop into several distinct types, in each case closely resembling the leaf characteristic of the species. We can therefore have little, if any, doubt that this growth is influenced by the form of the leaf.

The species in which a connexion may perhaps be traced between the characteristics of the leaves and those of the cotyledons are so few, that I may mention here that of *Embelia Ribes* (fig. 155). The leaves are simple, alternate, exstipulate, petiolate, alternately and incurvinerved, rather thick and indistinctly reticulate, shining on both surfaces, bright green above, paler beneath, and punctate with dark green sunken glands eventually becoming blackish, thinly glandular pubescent on both surfaces; petioles semiterete, channelled above, closely glandular pubescent, tapering downwards. The first leaf is broadly ovate, or short elliptic, acute, and serrate except towards the base. The second is similar, but less broad; the third, fourth, and fifth lanceolate, each rather narrower than the preceding.

Fig. 155.



Seedling of *Embelia Ribes.* Half nat. size.

The cotyledons are ovate, obtuse or subacute, indistinctly alternately incurvinerved, and reticulate, distantly serrate in the upper half, petiolate and tapering into the petiole, glabrous, bright green and shining above, paler beneath, thinly glandular on both surfaces, and dotted with sunken black glands; petioles semiterete, slightly furrowed above, finely glandular pubescent.

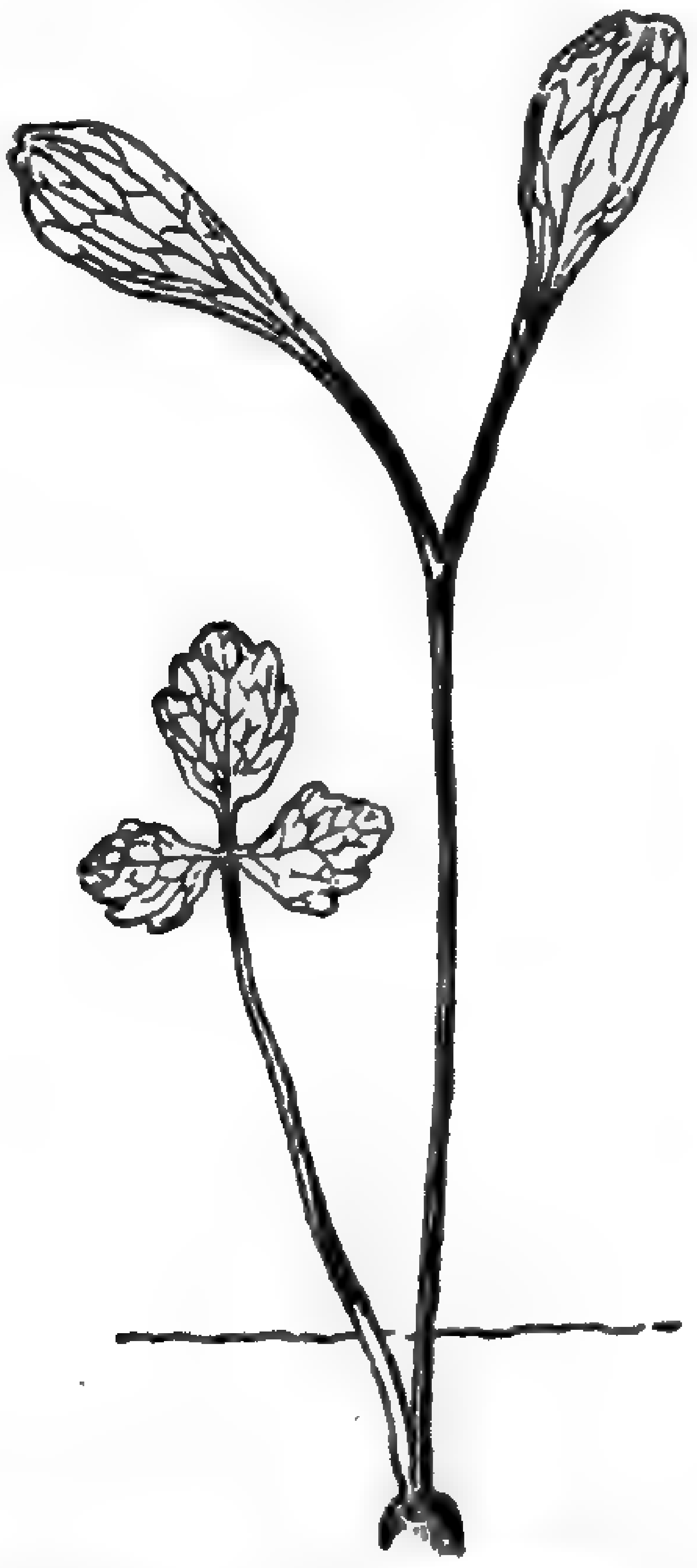
Here it will be observed that the cotyledons are strikingly like the first leaves; and, moreover, that there is a regular gradation from the broad ovate colyledon to the final leaves, which are narrow lanceolate. The serration of the cotyledons is a very rare character.

In this connexion also I may perhaps mention *Eschscholtzia tenuifolia*. In my previous memoir I described* and figured (*l. c.* fig. 40) the germination of *E. californica*, in which the cotyledons are long, narrow, and deeply bifid, and suggested that this form enabled them more easily to make their exit from the seed. In that species, where the cotyledons are deeply bifid, the leaves also are much cut up. In *E. tenuifolia*, on the contrary, both the leaves and cotyledons are long and linear. Here also the form probably facilitates the exit; and one may perhaps suggest that *E. californica* exhibits a form of which *E. tenuifolia* represents an earlier and simpler condition.

Connate Petioles.

In support of the suggestion which I made in my last paper with reference to the advantage of petioles being connate, I may give as additional evidence the case of *Smyrnium perfoliatum*

Fig. 156.



Seedling of *Smyrnium perfoliatum*. Half nat. size.

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* Journ. Linn. Soc., Bot. vol. xxii. 1886, p. 359.

(fig. 156). The caulicle is undeveloped, the cotyledons are oblong elliptic, emarginate, obtuse, generally unequal-sided or subfalcate, longly petiolate, 3-nerved from the base, and finely reticulate, with the lateral nerves becoming incurved and uniting with the midrib close to the apex, glabrous, light green above, paler beneath, shining on both surfaces; lamina 18–24 millim. long, 8½–11 millim. wide; petioles 60–100 millim. long, connate into one terete piece for 55–75 millim. of their length, split a little way at the base to allow the plumule to emerge, free in the upper part, semiterete and slightly channelled above, glabrous, shining, dull brownish green.

In this case it is obvious that if the petioles had been separate, they would have been far too weak to stand upright, and their length therefore would have been comparatively useless.

In *Polygonum polystachyum*, again, the petioles are connate and form a hollow tube through which the leaves pass; so that the seedling has the appearance of possessing an erect caulicle with nearly sessile cotyledons.

Unequal Cotyledons.

In my previous memoir I gave (*l. c.* p. 369) several cases in which the two cotyledons are unequal, and pointed out the reasons to which in the several instances this seemed to me to be due. ***Coreopsis Atkinsoniana*** **affords us a case which I then accidentally omitted. The seeds are obovate, curved longitudinally, and compressed dorso-ventrally, conforming to the interior of the**

Fig. 157.

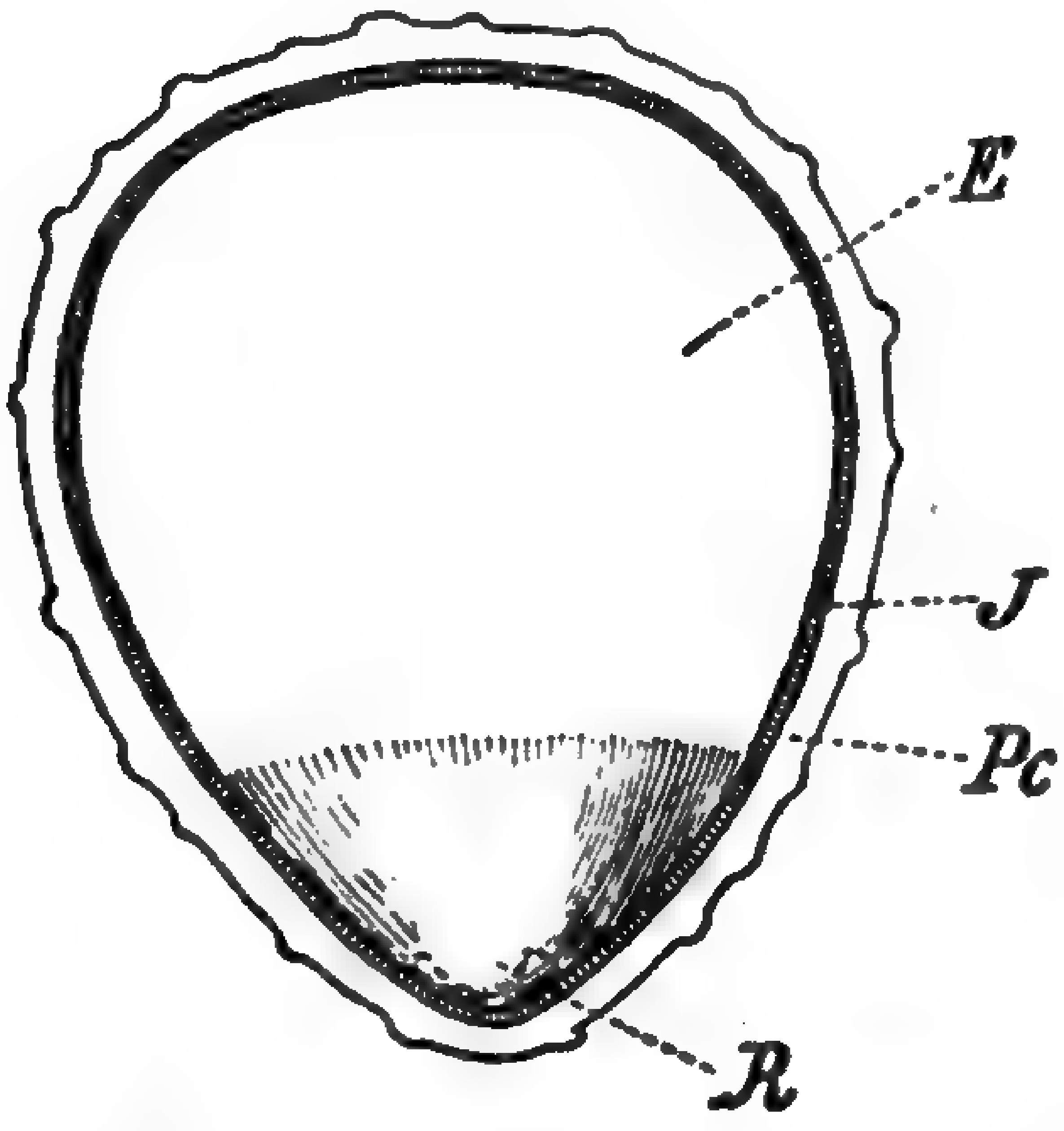


Fig. 158.

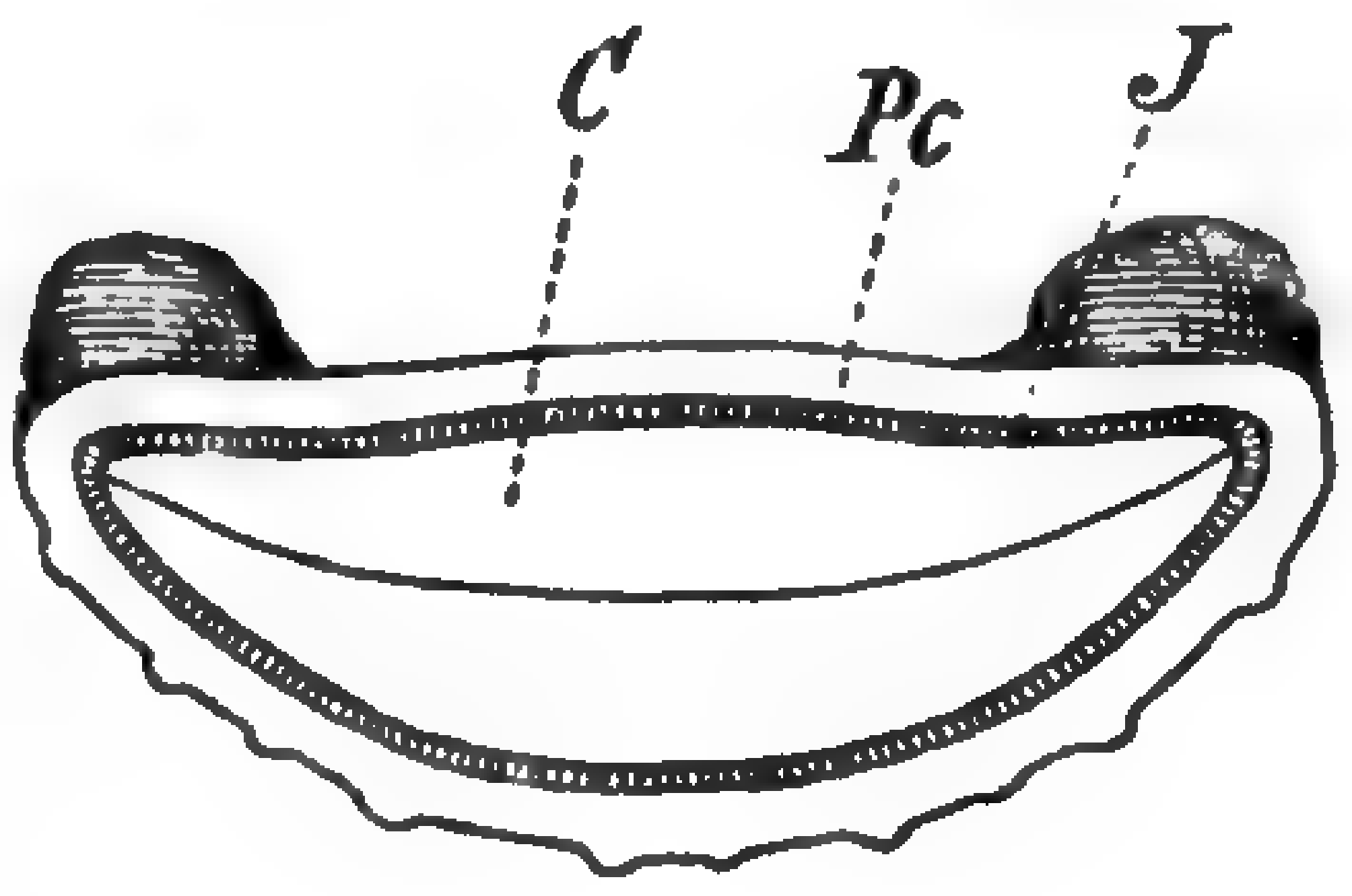


Fig. 159.

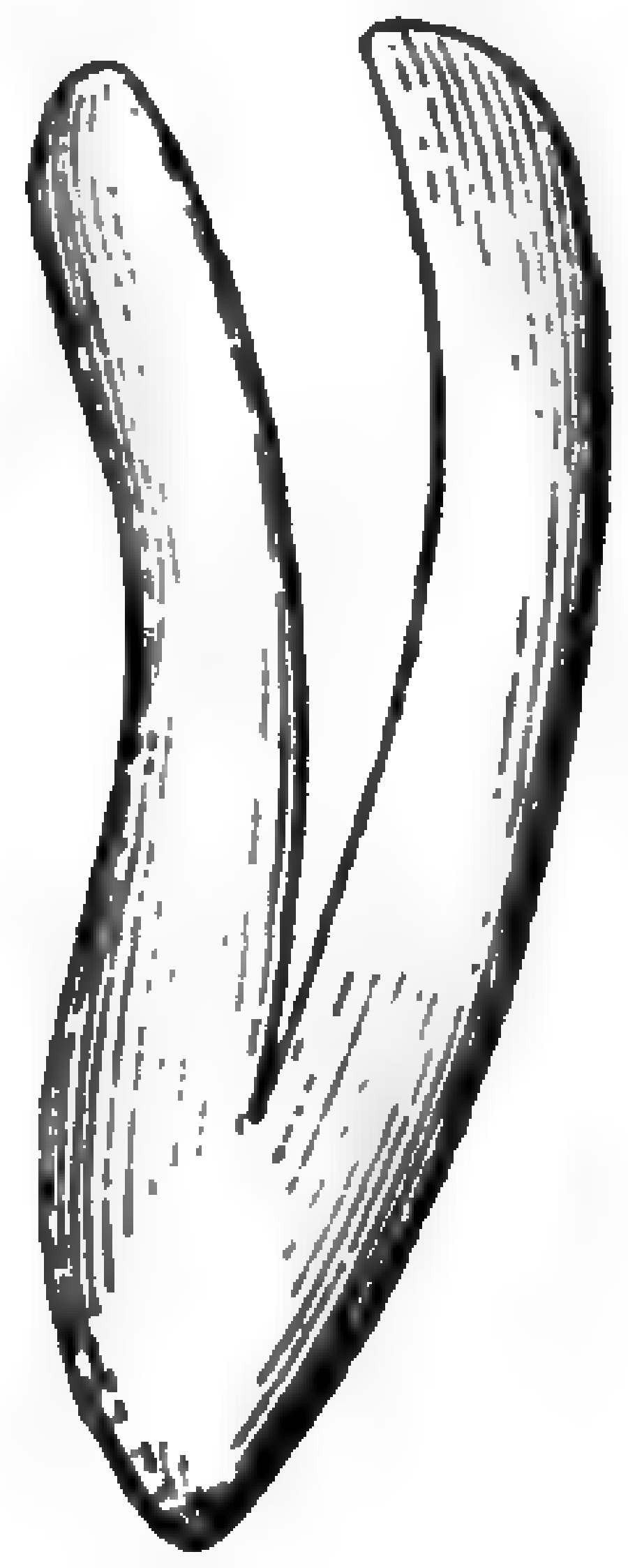


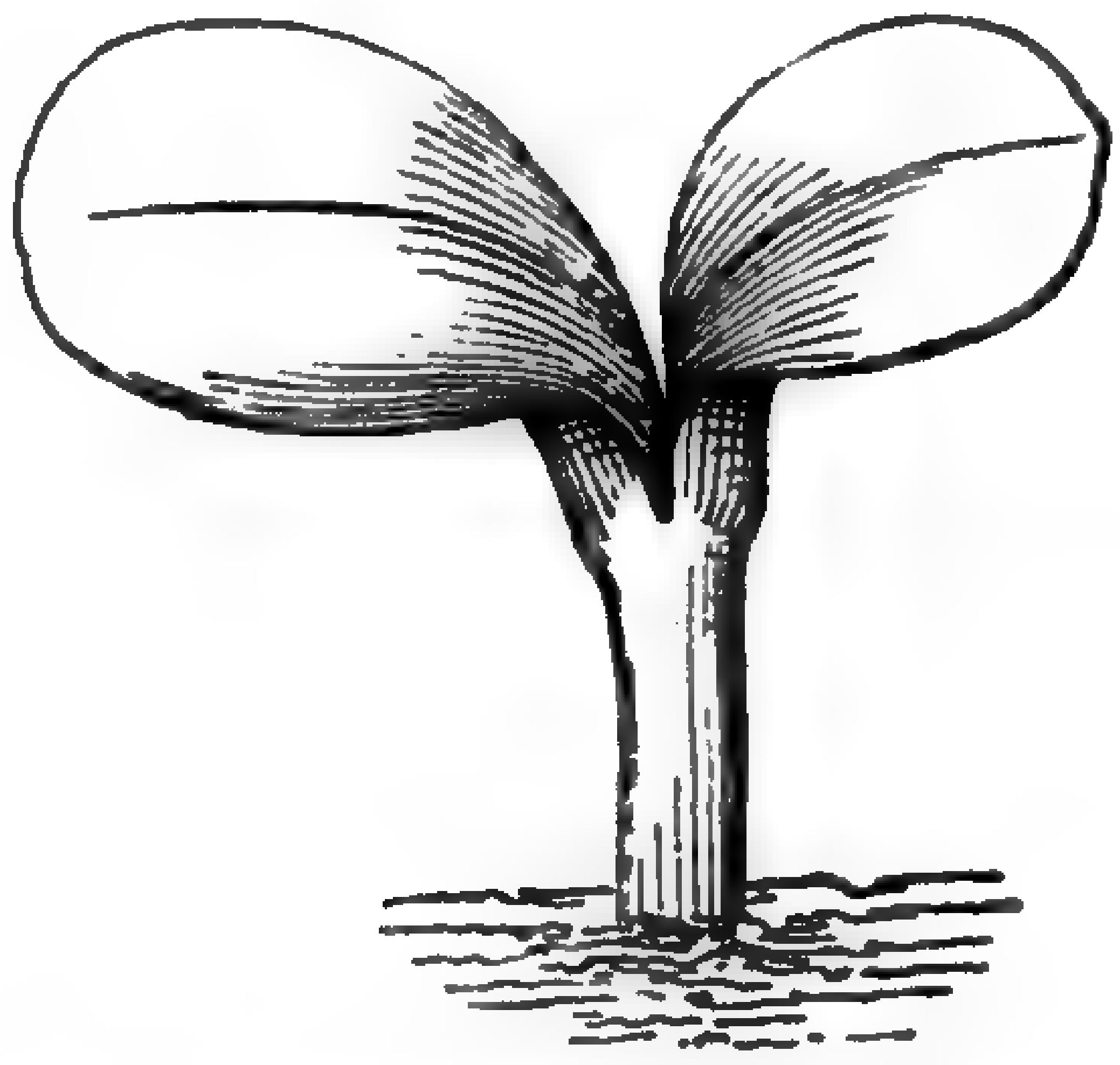
Fig. 157. *Coreopsis Atkinsoniana*: longitudinal section of achene. ×10.
Fig. 158. Ditto: transverse section of achene. × 10.
Fig. 159. Ditto: embryo. × 10.

fruit. The embryo again is slightly bent, following the direction of the seed. Consequently the one cotyledon occupies the inner, the other the outer side of the curve; and, as shown in fig. 160, the outer one is distinctly larger than the other.

The Hemp (*Cannabis*) and *Caylusea* present us with other cases more or less resembling that of *Hesperis* mentioned in my previous memoir.

In *Thunbergia reticulata* the cotyledons are unequal, ovate, obtuse, slightly emarginate, and cordate at the base. The larger one is slightly denticulated, and with a curious embossed patch in the centre; the smaller one is, on the contrary, smooth and entire, or nearly so. The seed is orbicular or oblong; aperispermic, 3–4 millim. in diameter, compressed, with a cavity on the inner side. The embryo is slightly curved; and the cotyledons lie with their faces towards the hilum, which is very prominent; the inner cotyledon is turned up at the edges, and wraps, to a certain extent, round the outer one. The raised or embossed patch in the centre of this cotyledon is due to the inward curvature of the testa.

Fig. 160.



Coreopsis Atkinsoniana. Seedling. × 10.

Position of the Embryo in the Seed.

Plantago.

As a general rule, the arrangement and position of the embryo in the seed is approximately the same within the limits of any one genus. There are, however, many exceptions. In the genus *Plantago*, for instance, the cotyledons sometimes have their faces and sometimes their edges to the placenta. This difference is not indeed mentioned either by Barnéoud or Decaisne in their respective monographs of the family. Bentham and Hooker, however, say (‘Genera Plantarum,’ p. 1223):—“Embryo rectus v. rarius hippocrepicus, hilo parallelus v. in fructu monospermo erectus v. transversus.”

In *P. media* the fruit is capsular, dry, membranous, 2-celled, and 2–4-seeded. The seeds (figs. 161 and 162) are plano-convex, or subconcavo-convex, peltate, small, with equal obtuse ends; or with the basal end slightly the broadest; the testa is thin, pale brown; hilum a little below the middle on the ventral aspect, round, deeper brown than the rest of the testa; the raphe tapers from the hilum obliquely towards the upper end of the testa. The perisperm is copious, fleshy, and white. The embryo is straight, narrow, white, a little shorter than the perisperm, and embedded in it, a little nearer the dorsal aspect of the seed and somewhat oblique to the median axis; the cotyledons are linear-spatulate, tapering towards the base, obtuse, entire, and with their faces towards the placenta; the radicle is inferior, obtuse, and shorter than the cotyledons.

Fig. 161.

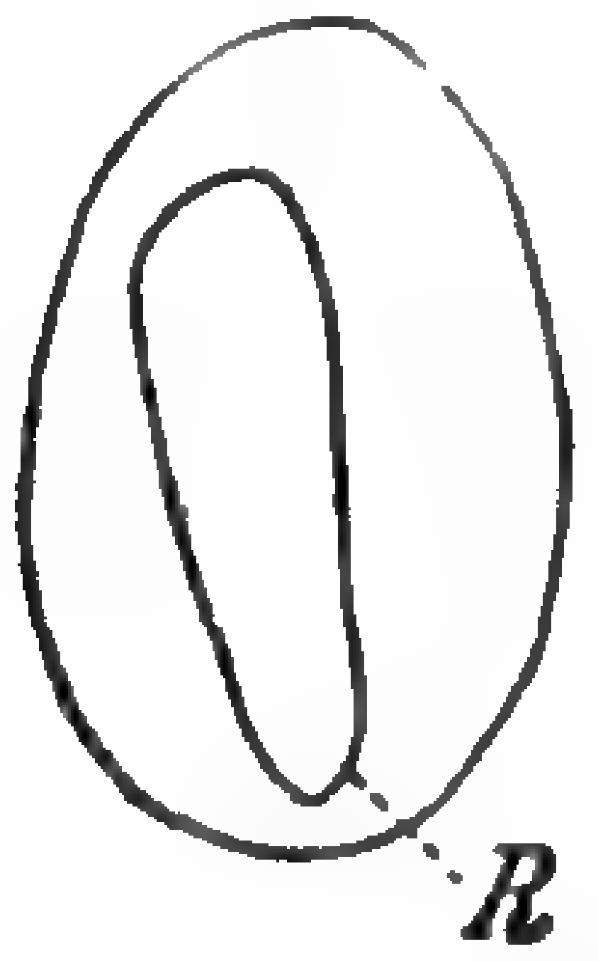


Fig. 162.

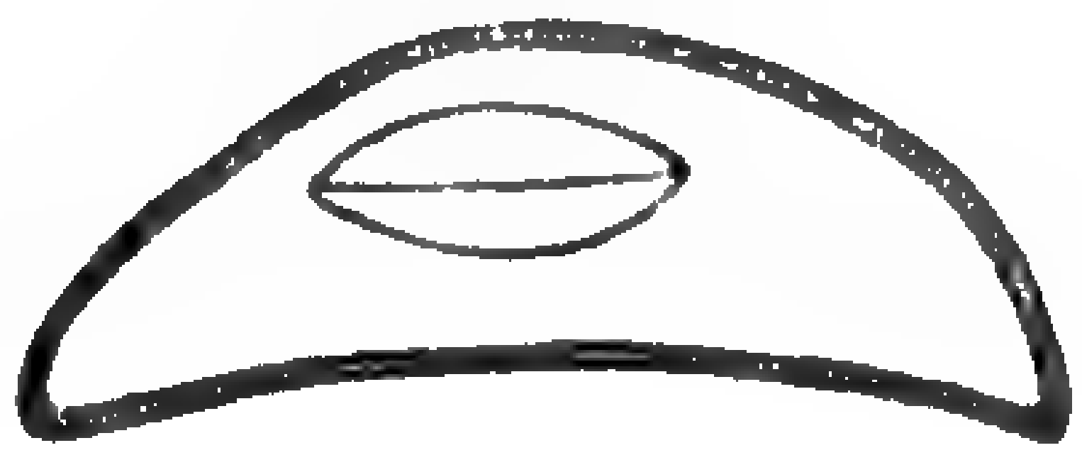
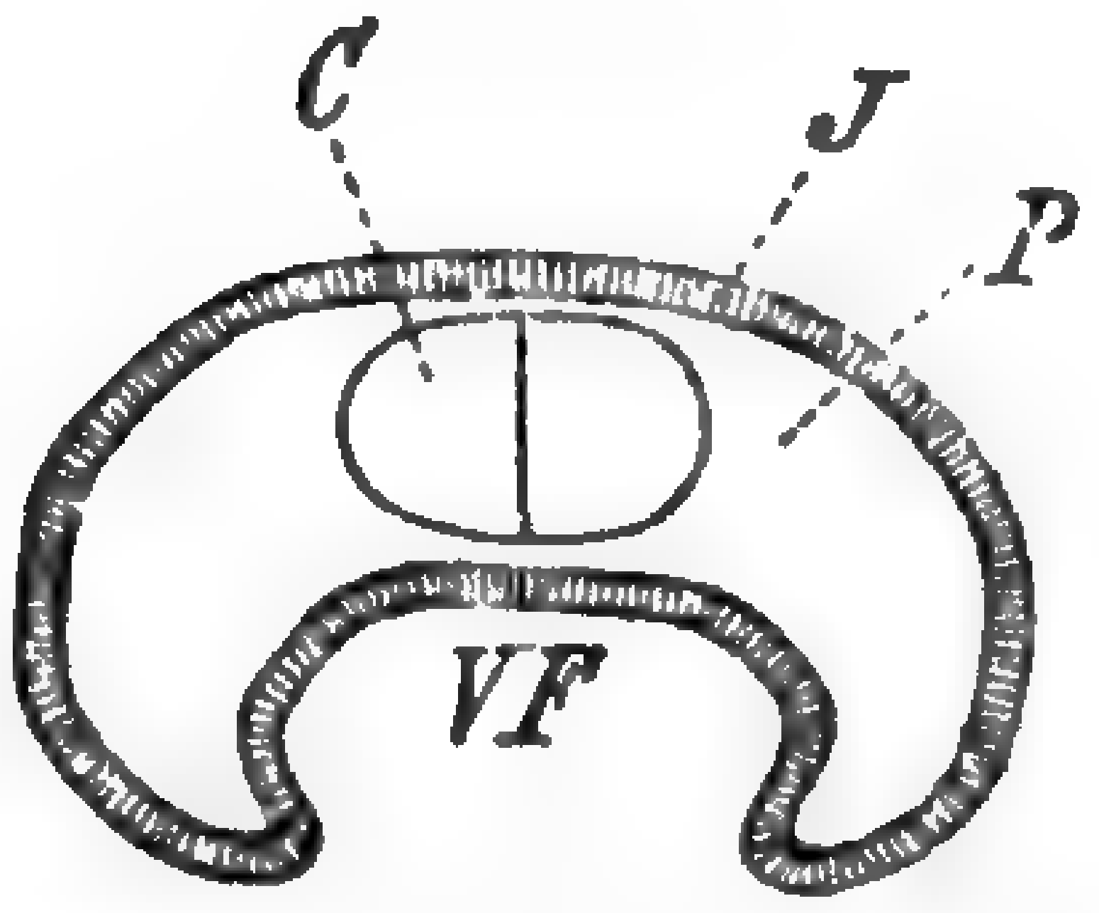


Fig. 161. *Plantago media.* Longitudinal section of seed. × 8.
Fig. 162. Ditto. Transverse section of seed. × 8.

In *P. lanceolata* (fig. 163) the capsule is also 2-celled, with one seed in each cell. The seed is concave on the ventral side, at first pale green, at length becoming yellow. The hilum is oval, forming a white or pale spot about or a little below the middle on the ventral aspect. The perisperm is abundant, fleshy, or subhorny when dry, and semitransparent. The embryo is straight,

Fig. 163.



Plantago lanceolata. Transverse section of seed. × 12.

white, embedded in the perisperm, and a little shorter than the seed. The cotyledons are narrowly oblong or linear, obtuse, plano-convex, closely applied face to face, and with their edges to the placenta. The radicle is narrower than the cotyledons, inferior, and tapering downwards.

In *P. Coronopus* the capsule is many-seeded. The seeds are oblong-oval, suddenly tapering to an obtuse point at the lower end, small, in transverse section somewhat diamond-shaped, with the angles rounded off, and attached to the placenta considerably below the middle. They are much smaller than those of *P. media*, and differ much among themselves. The embryo is comparatively large, straight, central, nearly equalling the perisperm in length; the cotyledons are linear obtuse, entire, plano-convex, thick, closely applied face to face, and with their edges to the placenta.

In *P. maritima* the fruit is narrowly ovoid, 2-celled, 2-seeded. The seed oblong-lanceolate, biconvex or flattened on the ventral side. The embryo is straight, large, and nearly fills the seed; the cotyledons have their edges to the placenta.

In *P. Cynops* the fruit is green, with a pale line where the two carpels come together, and a darker one along the middle of the carpel, giving it in a young state the appearance of consisting of four carpels, 2-celled, 2-seeded. The seed is ovate obtuse, peltate, compressed dorsally, concave on the ventral side, smooth, shining, deep green when young, and sufficiently transparent to show the embryo by transmitted light. The embryo is straight; the cotyledons linear, obtuse, entire, closely applied face to face, with their edges to the placenta.

In *P. arenaria* and *P. major* the cotyledons are also placed with their edges to the placenta.

I was for some time much puzzled as to why the cotyledons in *P. media* should be placed differently from the other species examined; though the reason seems in reality very simple. At first I thought it might have reference to the mode in which the embryo emerges from the seed; but this does not seem to have any bearing on it. In *P. lanceolata*, however, and its allies the cotyledons are narrow and thick; and the seed being somewhat compressed, it will be seen from fig. 163 that if the embryo had been placed with its faces to the placenta, it would not have had room to develop itself.

On the other hand, in *P. media* the reverse is the case: the cotyledons are thin and comparatively wide; their width, in fact, is greater than their thickness. It follows that if they had been arranged as in the other species, they would not have had room to develop themselves. The difference of position is therefore explained by the fact that in *P. media* the width of the cotyledons is greater than the thickness; while in *P. lanceolata* &c., on the contrary, the thickness of the two cotyledons, taken together, is greater than their breadth.

The normal arrangement of an embryo in the seed is to have the faces of the cotyledons turned to the placenta. There are, however, not a few cases in which, as in these species of *Plantago*, the cotyledons have their edges to the placenta. When this is the case, it may be suggested as possible that the position is due to the fact of the seeds being more or less, in some cases very much, flattened; and that the embryo is twisted round at right angles to its normal position, so that the cotyledons may lie in the broad way of the seed, as in *Ailanthus*, *Euonymus*, *Passiflora*, *Linum*, *Fraxinus*, *Diospyros*, *Heliotropium*, and many Crucifers, Leguminosæ, and Rosaceæ.

On the other hand, in the case of *Claytonia* this explanation will not apply. There would appear no reason, so far as the seed is concerned, why the cotyledons should not lie in the usual position.

It has occurred to me whether the arrangement of the cotyledons may have reference to their exit from the seed. If we

Fig. 164.

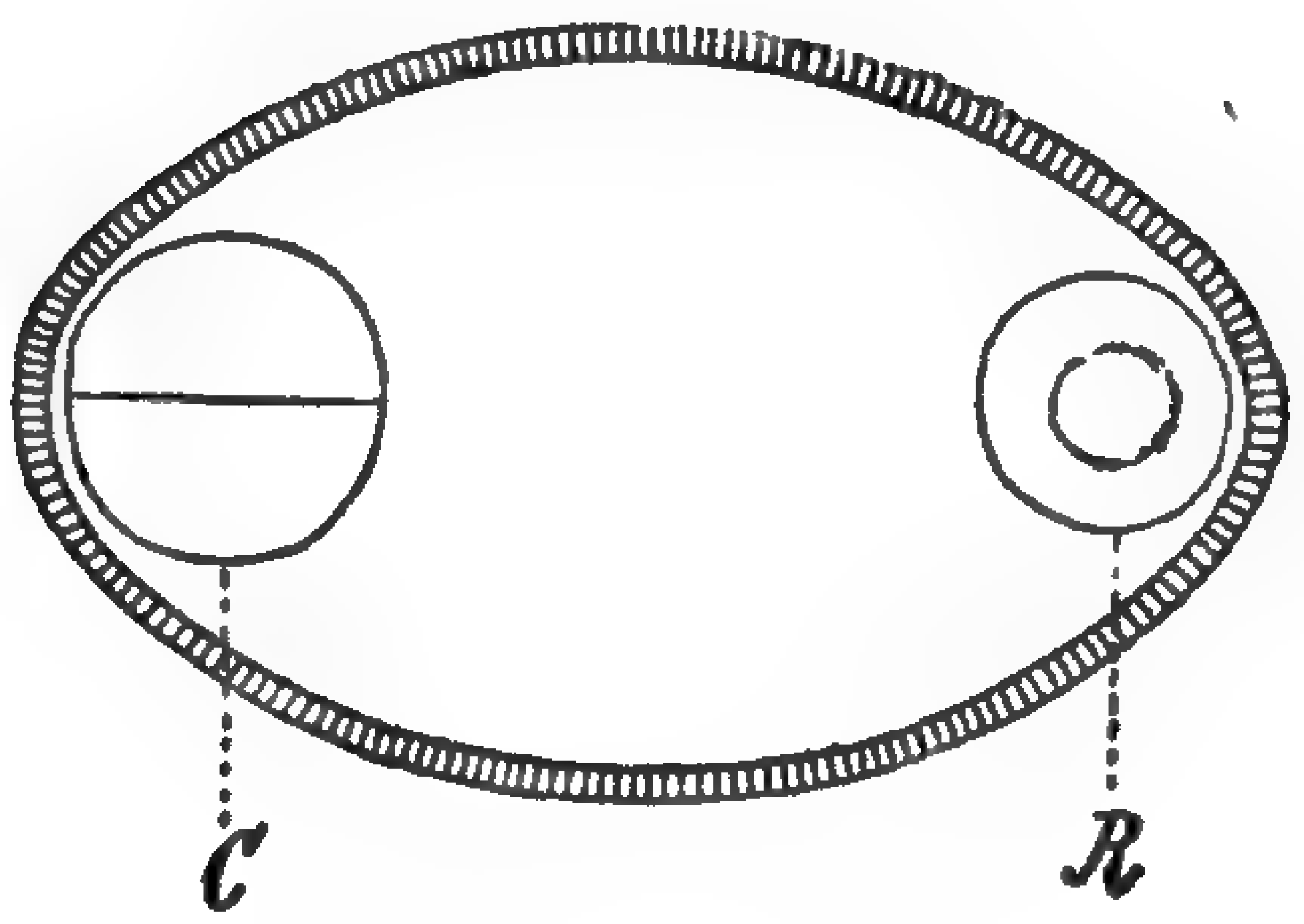


Fig. 165.

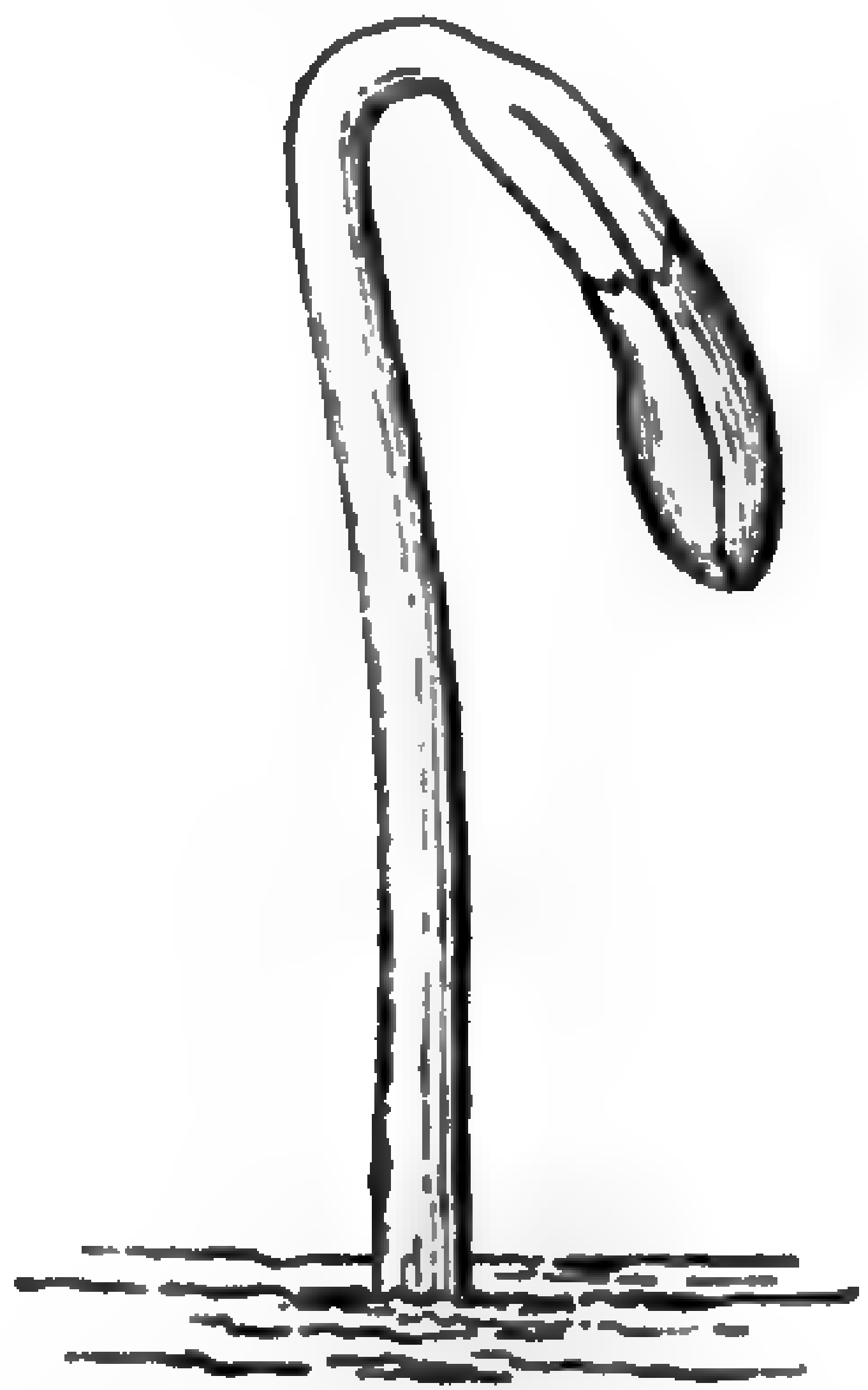


Fig. 164. *Claytonia perfoliata.* Transverse section of seed. × 15.
Fig. 165. Ditto. Seedling. × 6.

examine a germinating seedling of *Claytonia*, we shall see that the testa splits vertically from the micropyle, and the cotyledons from their position, when they separate, act with greater advantage in enlarging the orifice, and thus securing their exit, than they would if they occupied the more usual position. This, however, I only throw out as a suggestion which requires further investigation.

When the seed is flattened laterally, the embryo must either be narrow or lie with its edges of the cotyledons to the placenta.

For instance, in *Heliophila pilosa* var. *incisa* the seeds (figs. 166 & 167) agree closely in form with those of *Cheiranthus* (figs. 90 & 91, *C. Cheiri*); they are oblong-obtuse at each end, compressed dorsally, with a notch at one end, and in section are narrow elliptic; but while the cotyledons of *Cheiranthus* are broad, in *Heliophila* they are long and linear. The reason of this may be that while in *Cheiranthus* and other Arabideæ the pods are flattened dorsally and the cotyledons are accumbent in the broad way of the seed (figs. 90 & 91), those of the Sisymbreæ, to which *Heliophila* belongs, have (figs. 166 & 167) the cotyledons incumbent, so that they lie across the seed, and are consequently linear.

Fig. 166.

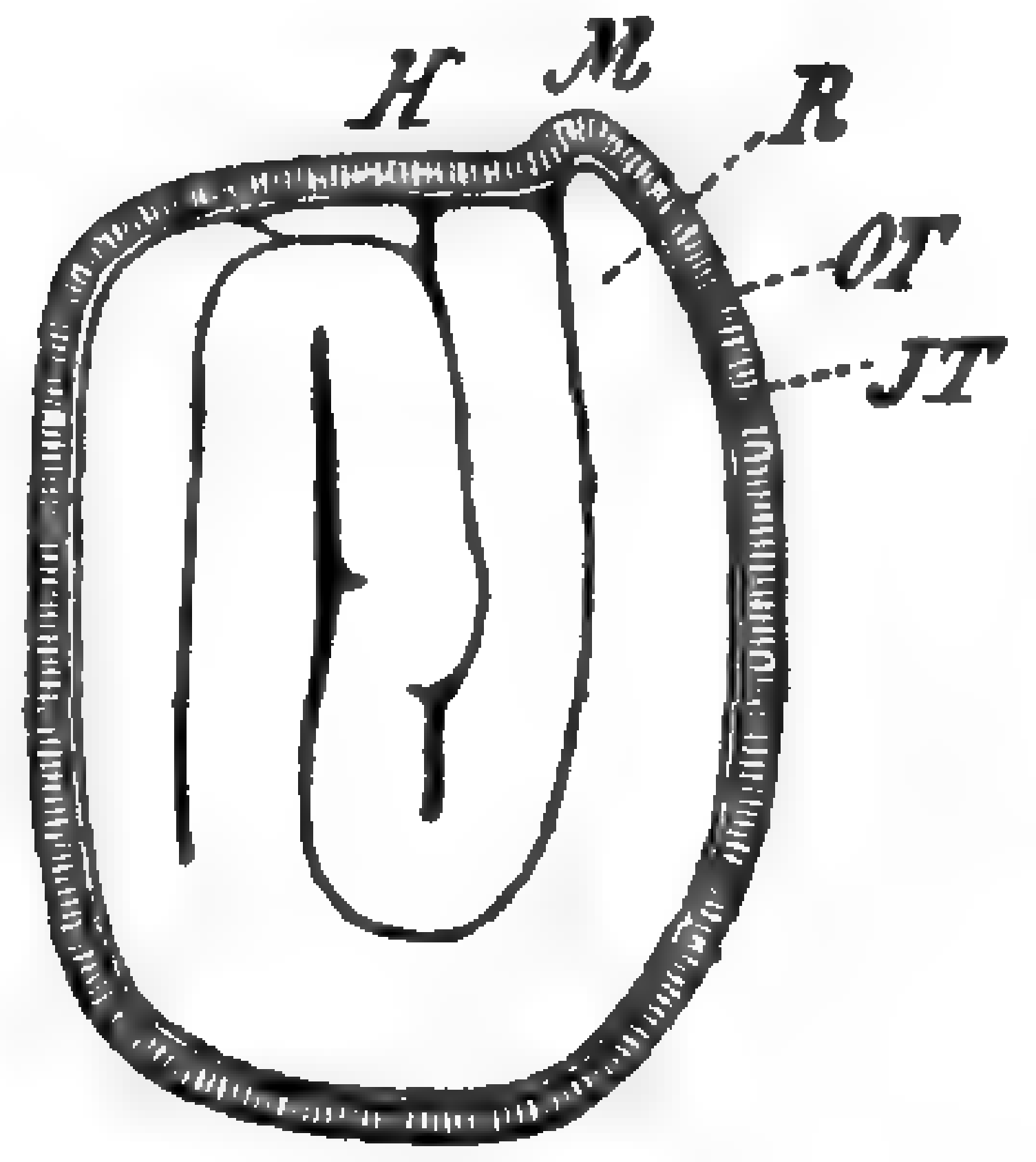


Fig. 167.

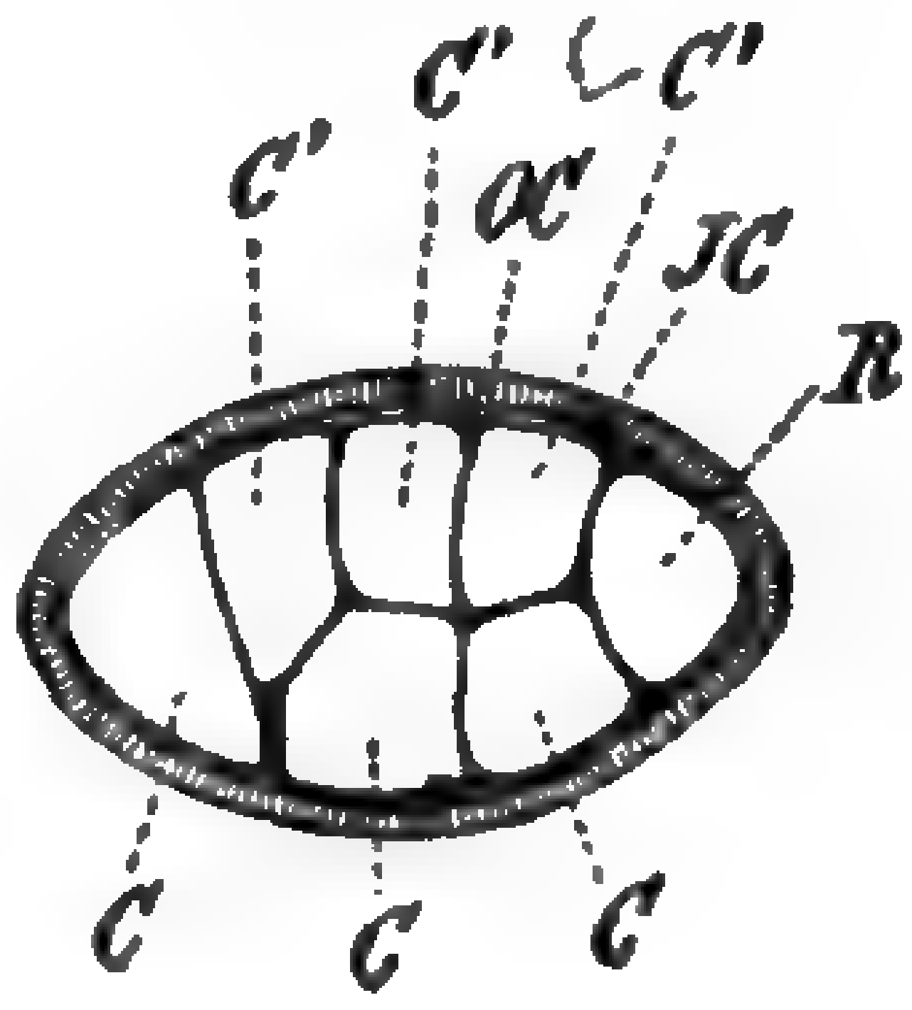


Fig. 166. *Heliophila pilosa.* Longitudinal section of seed. × 12.
Fig. 167. Ditto. Transverse section of seed. × 12.

Similar cases occur in other Orders, as for instance in Caryophylleæ and Solaneæ.

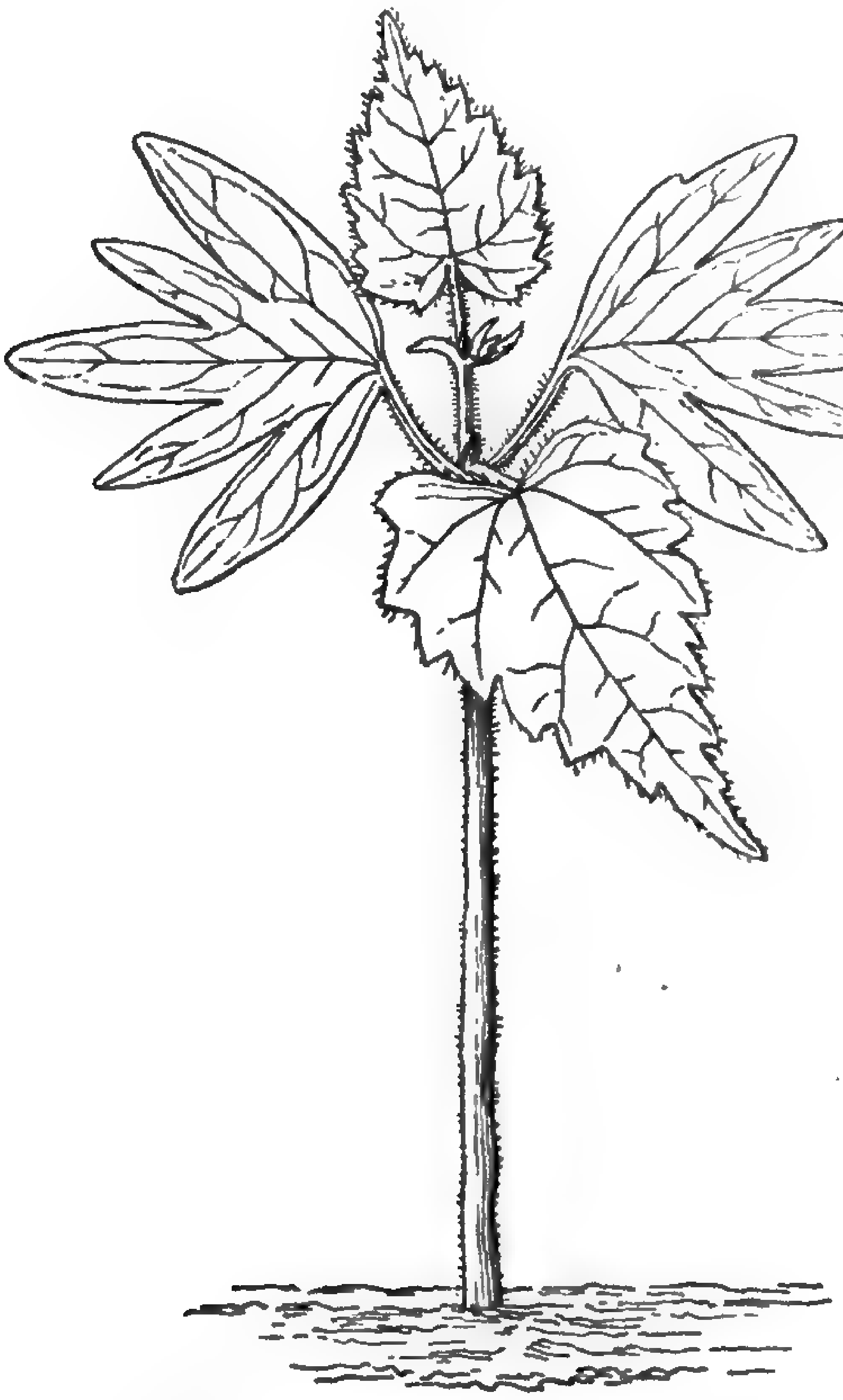
Divided Cotyledons.

Divided cotyledons are far from frequent; still in my previous memoir I described several cases, and pointed out the causes to which they seemed to me to be due.

In the Lime (*Tilia*, fig. 168) we have a different and very interesting case.

The cotyledons are broad, foliaceous, rhomboid-subtriangular, and 5-lobed, 5-nerved at the base, with the outer and lower pair of nerves slender, alternately nerved upwards, reticulate, shining and thinly pubescent on both surfaces, deep green above, paler beneath, petiolate; lobes oblong-obtuse, with a strong nerve running into each, the basal ones always largest and sometimes ovate; middle pair of lobes always the smallest, and oblong or subulate; lamina 15–21 millim. long, 17–25 millim. from tip to tip of the basal pair of lobes; petiole semiterete, shallowly channelled above, pubescent, 6–8 millim. long.

Fig. 168.



Tilia vulgaris. Seedling. Nat. size.

The fruit is an ovoid or subglobose nut, with five obtuse angles, tomentose with somewhat rufous hairs, one-celled by the rupture of the septum, one-seeded, indehiscent, tipped with the persistent base of the style, woody, attached to a large deciduous bract which serves to disseminate it by the aid of the wind.

The seed is ascending or erect, obovoid or subglobose, deep brown, smooth, with a firm or crustaceous testa of two distinct layers; hilum oval, comparatively large on the ventral aspect a little above the base, and longitudinal; raphe ventral, proceeding from the hilum to the apex of the seed; chalaza apical, prominent externally as well as internally in the mature state by a deeper brown blotch; radicle inferior.

The perisperm in the mature seed is copious, firm, pale yellow, and homogeneous. There is therefore so far nothing in any way analogous to the causes which have led to the existence of the lobes in the species previously described.

The embryo is at first straight; the radicle is stout and obtuse; the cotyledons ovate obtuse, plano-convex, fleshy, pale green, and applied face to face. They grow, however, considerably; and when (fig. 169) they meet the wall of the seed they bend back on themselves, and then curve round, following the general outline of the seed (fig. 170). If any one will take a common tea-cup and try to place in it a sheet of paper, the paper will of course be thrown into ridges. If these ridges be removed and so much left as will lie smoothly inside the cup, it will be found that the paper has been cut into lobes more or less resembling those of the cotyledons of *Tilia*. Or if, conversely, a piece of paper be cut out into lobes resembling those of the cotyledons, it will be found that the paper will fit the concavity of the cup. The case is almost like that of our own hand, which can be opened and closed conveniently owing to the division of the five fingers.

Fig. 169.

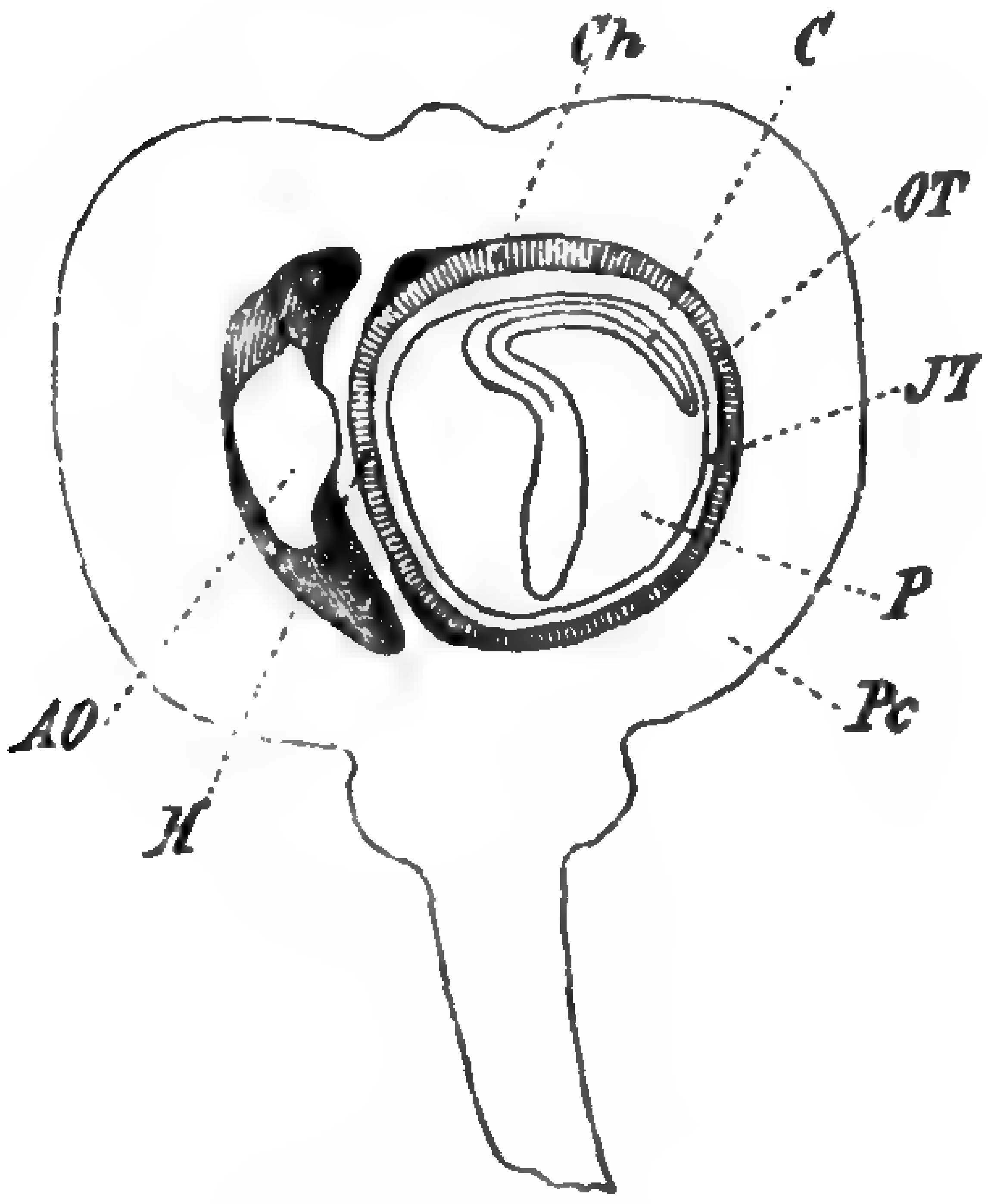


Fig. 170.

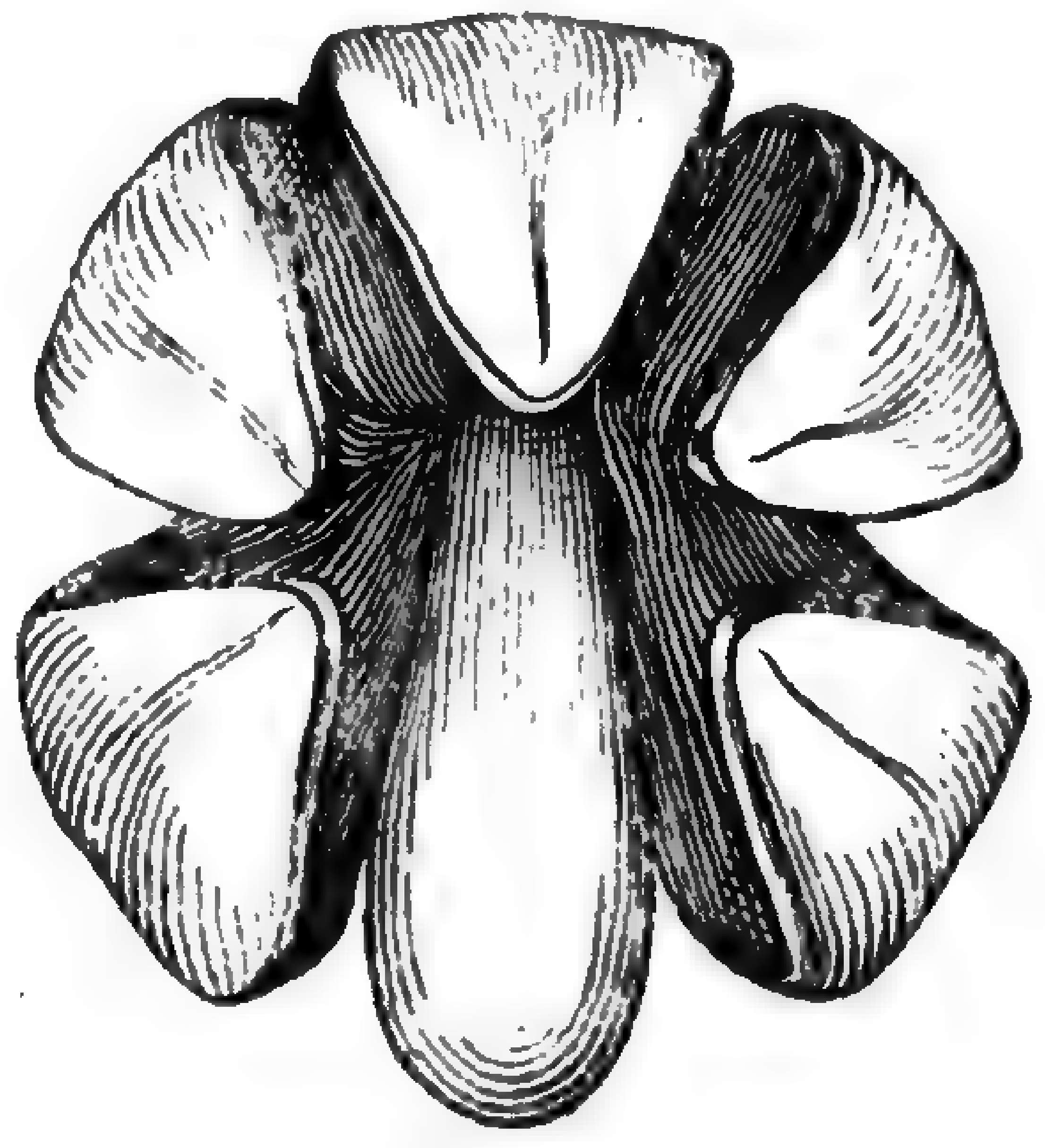


Fig. 169. *Tilia vulgaris.* Section of seed. × 4.
Fig. 170. Ditto. Embryo. × 8.

It may be said that the seed of the Sycamore (*Acer*) is not very dissimilar in form to that of the Lime (*Tilia*); and yet the cotyledons are long, narrow, and strap-shaped, while those of the

Lime are rhomboid and five-lobed; but it must be remembered that in the Sycamore the embryo occupies the whole seed, while in the Lime it is embedded in perisperm.

The peculiar lobed form of the cotyledons of *Tilia* enables them, I would suggest, to lie conveniently in the globose seed.

On the Form of the Leaf in the Tulip-Tree (Liriodendron).

The leaves of the Tulip-Tree (*Liriodendron*) have long attracted attention from the peculiarity of their form. I am not aware that any attempt has been made to account for this, though Mr. Meehan has an interesting note on the stipules of *Liriodendron* in the 'Proceedings of the Academy of Natural Sciences of Philadelphia'*. "The premorse or cut-off appearance of the blade," he says, "results from the stipular portions being adnate with the stem-axis, instead of being wholly on the petiole as in *Magnolia*." I confess I do not understand this, and am not even quite sure whether he himself regards it as an explanation; since he subsequently says, "It may be here noted that those who look only to Mr. Darwin's principle of natural selection to account for the laws of form, might be troubled by such cases as these. It is scarcely conceivable that a square-edged leaf-blade, as we find it in *Liriodendron*, is of any special benefit to the species; yet if this form is the consequence of some other act, which is a benefit; the selection principle may still hold good" †.

I infer from this that Mr. Meehan remains in doubt as to the cause of the very peculiar form presented by the leaf of this species.

Mr. Newberry has recently contributed to the 'Bulletin of the Torrey Botanical Club' (Jan. 1887) a notice on the "Ancestors of the Tulip-tree;" but the ancestral condition does not appear to throw any light on the question, nor is there any other existing species to which we can look for guidance.

The leaves of the Tulip-tree are saddle-shaped, abruptly truncate at the end, or, in the words of Bentham and Hooker, "sinuato 4-loba." I have often wondered what could be the purpose or the advantage to the tree of this remarkable shape. One idea which occurred to me was that the differences of form might enable insects to perceive the tree at some distance, just as the colours of flowers are an advantage in rendering them more conspicuous. I then looked closely to see whether the peculiar forms could in any way be explained by the position of the leaves on the tree. I believe, however, that the cause is of a different nature, and has reference to the peculiar character of the bud.

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* *L. c.* 1870, p. 114.

† *L. c.* 1870, p. 116.

Each young leaf is, as in the Magnolieæ generally, originally enclosed in, and sheltered by, the stipules of its predecessor. These are in *Liriodendron* oval, or in form resembling a shallow dish or spoon, so that, when placed face to face, they form a hollow almond-shaped body. The first of these neat little boxes which I opened showed the young leaf in the stage shown in fig. 171, *p* being the petiole, *l* the lamina of the leaf, and *s* that of the stipules. This threw me off the scent, as it seemed to afford no clue whatever to the peculiar form of the leaf. Eventually, however, on examining younger buds, I found what I believe to be the true explanation. Within the stipules of such a bud as that represented in fig. 171 are contained several younger buds, one within the other. The youngest stage which need here be mentioned is represented in fig. 172. The petiole is short and thick, the lamina is widest in the middle, and tapers regularly towards both base and apex; the stipules are in the form of a hemisphere. Gradually the stipules become more oval (fig. 173), assuming an almond-like form, somewhat thickest in the middle, tapering away to the sides, and more gradually towards the apex. The petiole has also elongated, and the lamina of the leaf is more abruptly turned downwards; so that the petiole passes up one side of the stipule, while the midrib passes round the tip of the stipule and down again the other side. The lamina itself has considerably enlarged, is conduplicate or folded on itself, lies on one side of the stipule, between its own stipule and one of those by which it is enclosed. It has also considerably modified its form, and for the following reason. The young stipule at its central part touches the surrounding older stipule, so that the young leaf cannot find room between them; while, on the other hand, at the sides and towards the end of the young stipule there is plenty of space for growth. This, I would suggest, accounts for the peculiar shape it assumes. Suppose, for instance, we lay an almond on a table and place a piece of glass over it, the glass will touch the almond on a surface *a* (fig. 175). In the case of *Liriodendron*, from the form of the bud the surface of contact occupies not only the oval (*a*), but also the space lying below the line *b*. The young leaf therefore, which I have indicated in fig. 173 by dots, cannot retain its original form of lamina, because it is stopped by want of space along the line *a*, which it will therefore follow, as shown in fig. 176. Moreover, the thickened rib or vein (figs. 171 & 174) will be arrested sooner than the thinner lamina. When stopped by meeting the stipule, it bifurcates; and this perhaps is one reason why the leaf permanently retains the form which it is thus compelled to assume. The lamina grows for a while somewhat more rapidly than the stipule, then the stipule more

Fig. 171.

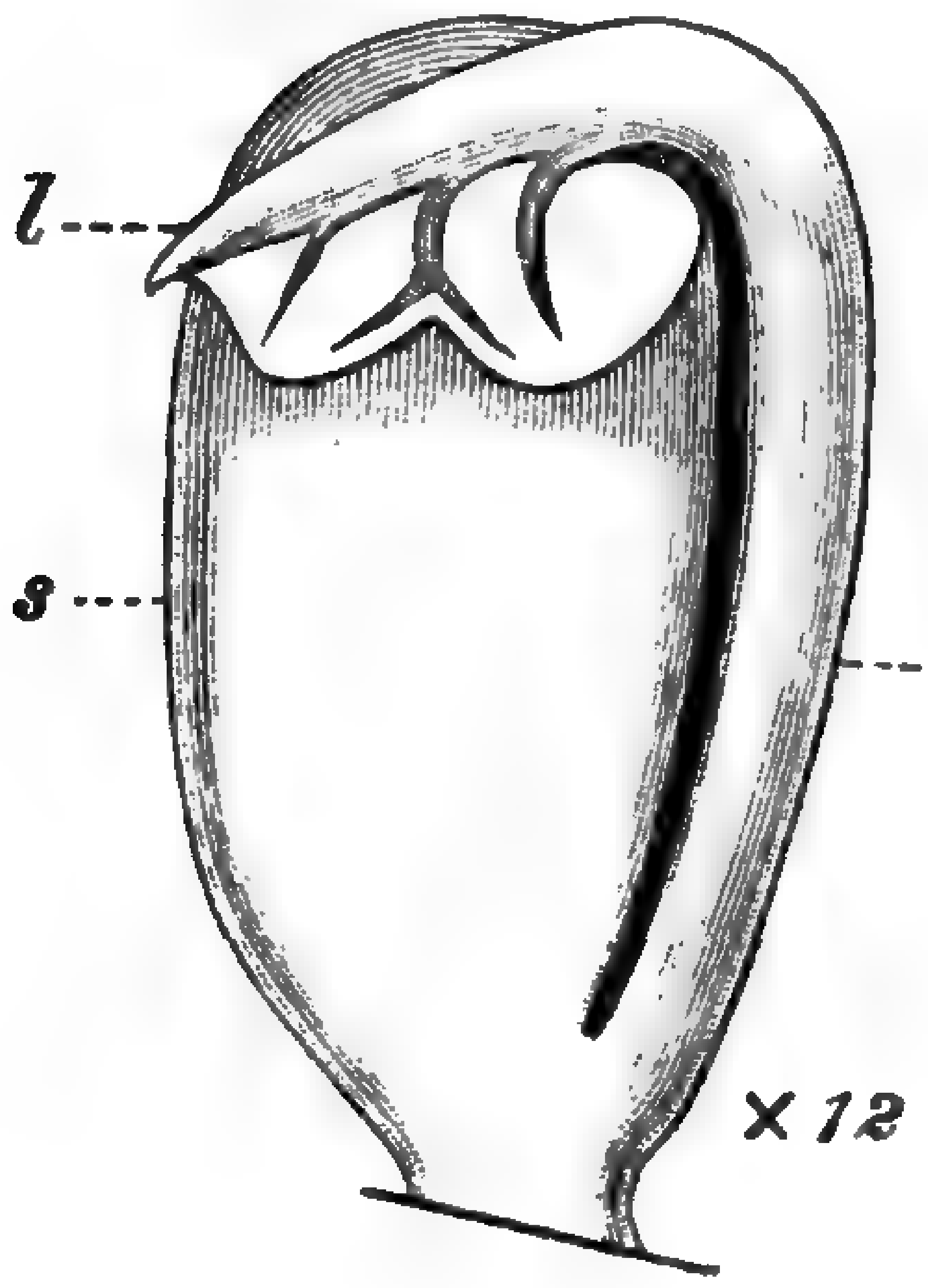

Fig. 172.

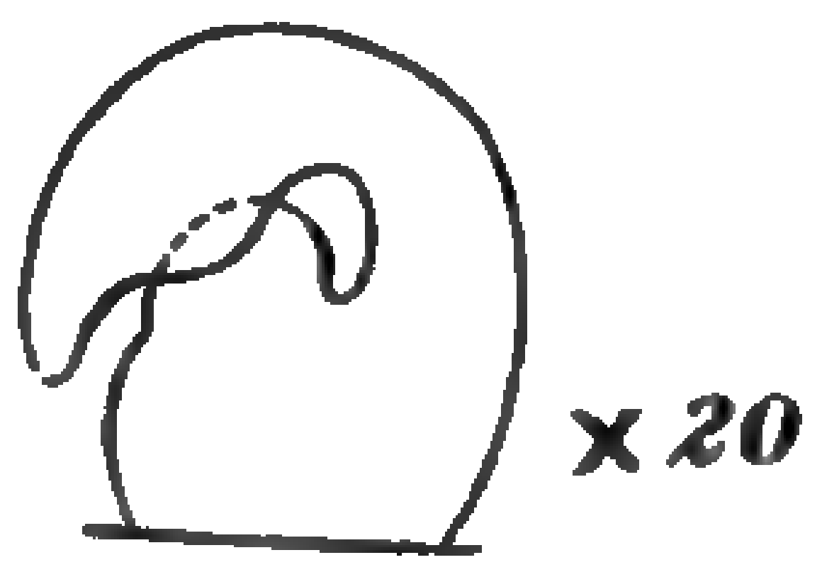

Fig. 173.

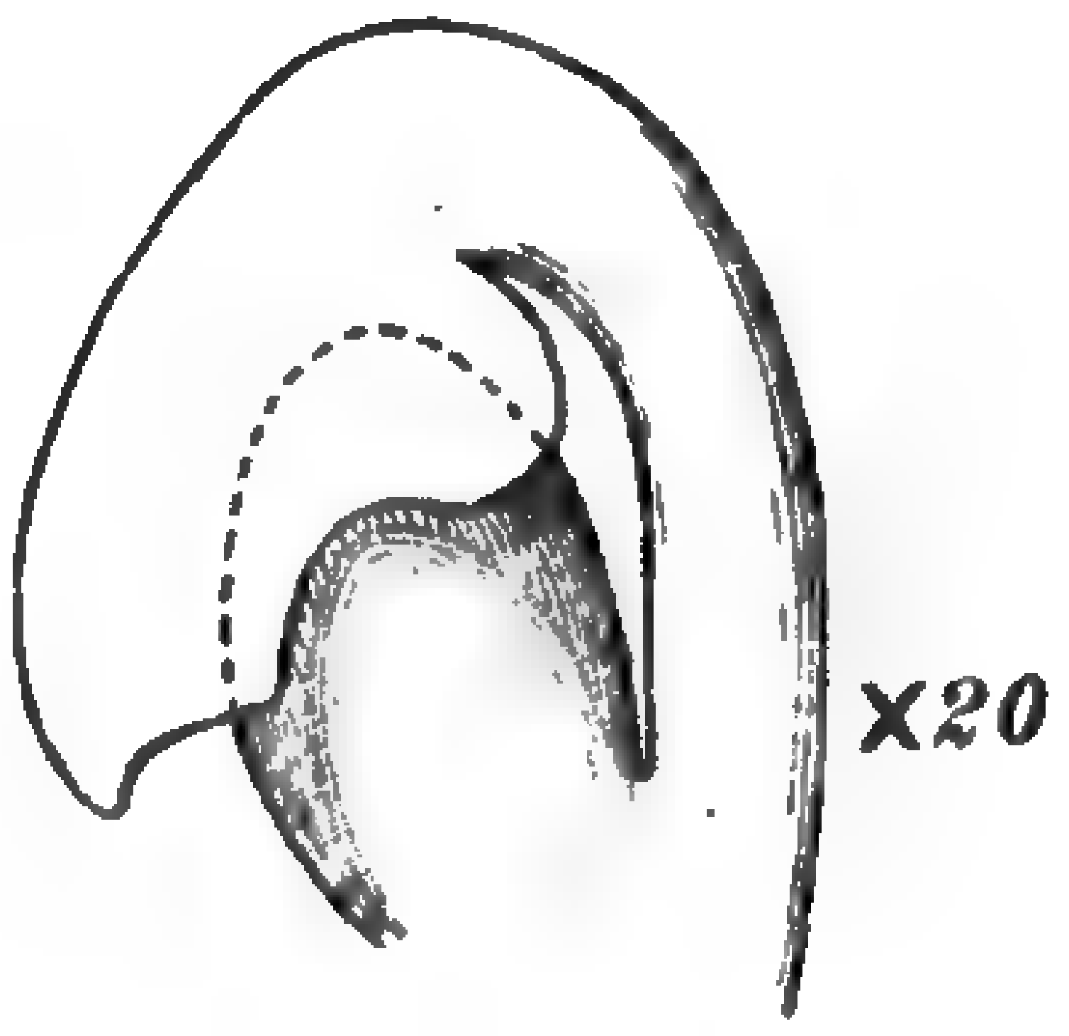

Fig. 174.

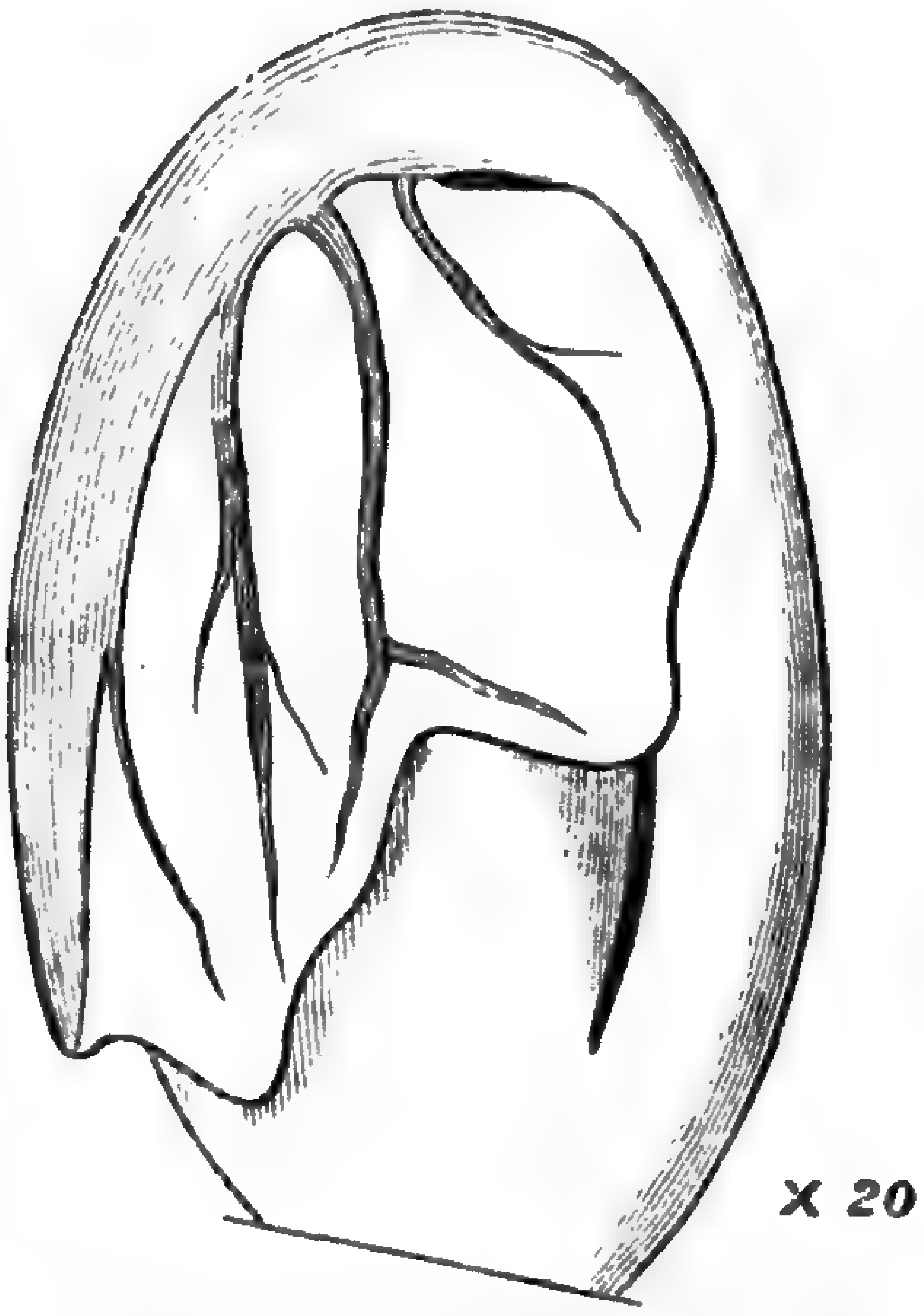

Fig. 171. *Liriodendron.* Position of young leaf in bud. ×12.
Fig. 172. Ditto. Very young leaf and stipule. × 20.
Fig. 173. Ditto. Ditto. Second stage.
Fig. 174. Ditto. Young leaf and stipule in a rather more advanced stage.

rapidly than the lamina; and, lastly, the growth of the stipule is arrested while the leaf attains a considerable size. The terminal portion of the young leaf seems narrower in fig. 174 than it is in the leaf; but it must be remembered that it is to some extent curved round the inner stipule, so that in the figure it is somewhat foreshortened.

Fig. 175.

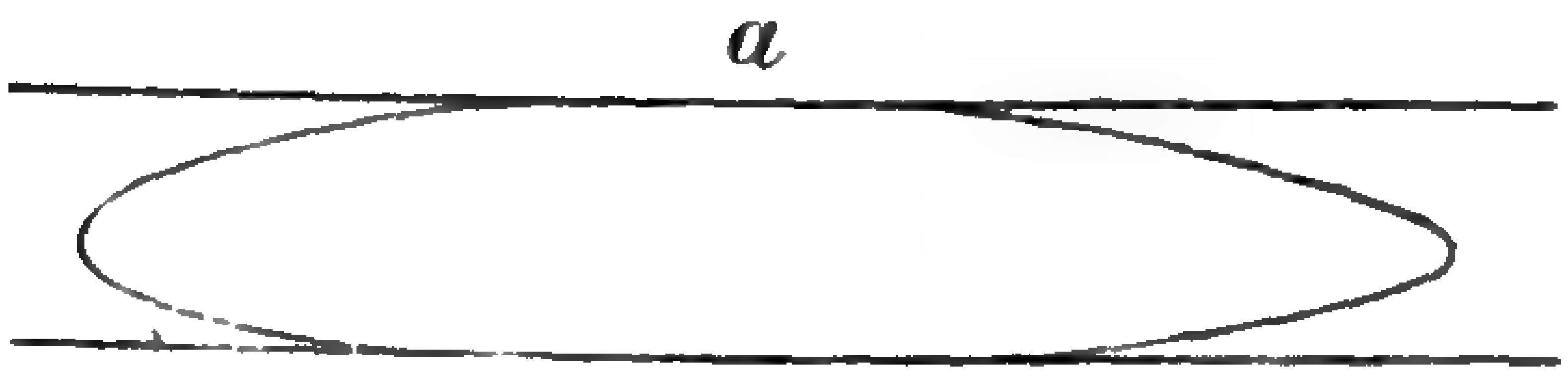

Fig. 176.

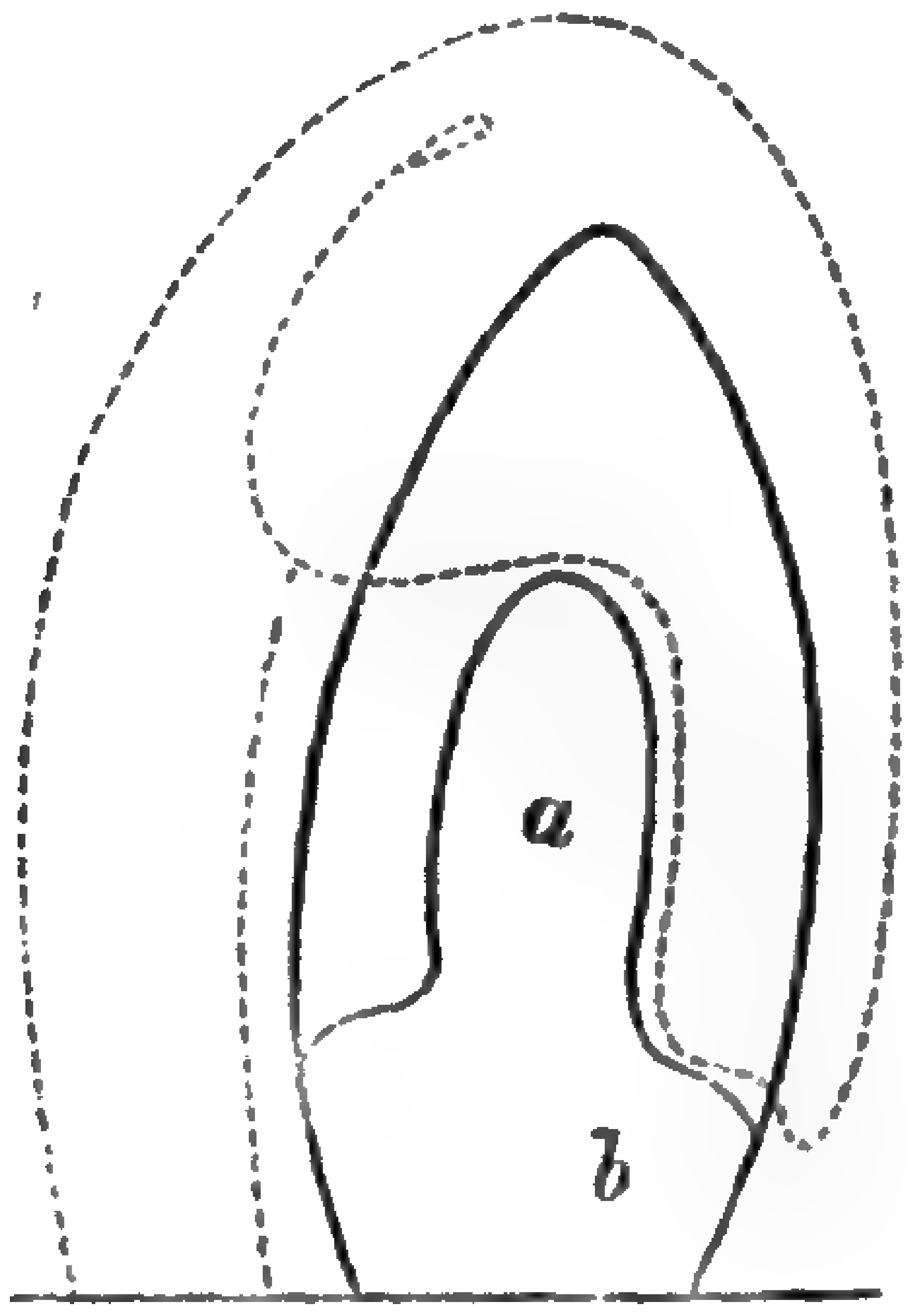

Fig. 175. Almond-shaped body on and under a glass.
Fig. 176. Diagram showing arrangement of the young leaf.

It might be suggested that the form of the leaf determines the bud. But in fact the form of the bud is not that of the leaf; the leaf follows, not the form of the bud, but that of the vacant space left in the bud.

I think that the explanation I have suggested accounts for all these points, and beautifully explains the peculiar form assumed by the leaf.

Since this was written, our Secretary Mr. B. D. Jackson has kindly called my attention to a note by M. Godron, "Observations sur les Bourgeons et sur les Feuilles du *Liriodendron tulipifera*" (Bull. Soc. Bot. de France, 1861, p. 33). M. Godron clearly describes the arrangement and form of the buds of *Liriodendron*. He attributes the square termination of the leaf to the fact of its abutting against the base of the bud. He does not give any suggestion as to the projecting point at the midrib, or the peculiar saddle-like shape of the leaf.

Experimental Observations on certain British Heterœcious Uredines. By CHARLES B. PLOWRIGHT, F.L.S.

[Read 5th May, 1887.]

PUCCINIA PHALARIDIS, n. sp.; soris minutis, punctatis, vel linearibus, nigris, epidermide tectis; sporis lævibus, brunneis, sessilibus vel perbreviter pedicellatis, quadratis vel infra attenuatis, truncatis vel supra conglobatis, interdum oblique capitatis, paulum constrictis.

I. *Æcidiospores.*—Cups mostly hypophyllous, in circular clusters on yellowish spots, not very prominent, with whitish, rather torn edges. Spermogonia appearing first upon the upper surface of the leaf centrally, then surrounded by the cups. Spores roundish, yellow, 20 to 25 mk.

II. *Uredospores.*—Sori orange, elongated, oval, oblong, or linear, small, sometimes confluent, at length naked. Spores subglobose or oval, orange-yellow, echinulate, 20 to 25 mk.

III. *Teleutospores.*—Sori minute, punctate, or linear, black, covered by the epidermis. Spores smooth, brown, sessile, or with very short pedicels, quadrate or attenuate below, truncate or rounded above, sometimes obliquely capitate, slightly constricted. The spores are surrounded by a bed of dark brown tissue, the individual fibres of which are not easily demonstrable; 40 to 50 mk. long, by 15 to 18 mk. wide.

I. *Æcidium Ari*, Desmaz. Catal. des Plantes omiss. 1823, p. 26; Cooke, Handb. p. 545. On *Arum maculatum*, L.

II. and III. On *Phalaris arundinacea*, L.

One of the more uncommon of our British Uredines is the *Æcidium* which occurs in spring and early summer upon *Arum maculatum*. This is the more striking because, not only is the host plant abundant, but also from the nature of its foliage and the manner of growth of the *Æcidium*; the latter, when it does occur, is very conspicuous, and hence unlikely to be overlooked. It is accompanied by no other spore-form upon the *Arum*, and is regarded as an heterœcious species, the affinities of which are unknown. During the months of May and June, 1884, I was fortunate enough to meet with this *Æcidium* in a lane at Gayton, near King's Lynn. This lane is about two miles long, and on both sides of it the *Arum* was growing in abundance; but in one spot, and in one spot only, extending for not more than a dozen yards, could the *Æcidium* be found. Repeated visits to the spot, and a careful examination of the Grasses and Carices in its immediate vicinity, led to the conclusion that the corresponding spore-forms probably occurred upon *Phalaris arundinacea*. There was only one cluster of this grass in the lane, and this was at the spot where the *Æcidium Ari* occurred. Moreover, the *Phalaris* was affected very extensively with a *Puccinia*. Upon microscopic examination these teleutospores corresponded so closely with those of *P. sessilis*, Schn., as to be practically undistinguishable from them in form and size—the only point of difference being that in my plant the teleutospores were surrounded by a bed of dark brown tissue, very much like that of *P. rubigo-vera*, but the individual hyphæ were not at all easy to separate. Although this character is not mentioned in connexion with *P. sessilis*, yet it might be due to some accidental condition of growth; so that I was, at first, rather doubtful as to the possibility of my plant being connected with the *Æcidium* of the *Arum*; for *P. sessilis* has been proved to have its æcidiospores upon *Allium ursinum*. On the other hand, I had previously met with a *Puccinia* on *Phalaris*, near King's Lynn, which I had always taken for *P. sessilis*; and had, upon more than one occasion, tried to infect *Allium ursinum* with it, but always without success. In fact, the connexion between *Æcidium Allii* and *P. sessilis* had always been a puzzle to me, for the *Æcidium* does not occur in this locality, although the supposed *P. sessilis* does.

On 25th April, 1885, a series of cultures were made with the *Puccinia* on *Phalaris*, from Gayton, upon seven plants of *Arum maculatum*. In the course of eleven days the spermogonia began to manifest themselves and, in due time, the *Æcidium*. Conversely, a number of cultures were made with the spores of *Æcidium Ari* on *Phalaris*, which gave rise to the *Uredo* and *Puccinia*. The *Uredo*, furthermore, was found to differ from that of *P. sessilis* in having yellow instead of brown uredospores. A duplicated experiment was also made, in which a quantity of freely germinating *Puccinia*-spores was divided into two portions, one of which was placed on a plant of *Arum maculatum* and the other upon several plants of *Allium ursinum*. The *Arum* became affected with the *Æcidium*, but all the *Allium* plants remained free. Hence it is evident that *Æcidium Ari* is an heterœcious uredine, having its corresponding uredo- and teleutospores upon *Phalaris arundinacea*; and that it is specifically distinct from the plant described by Schneider as *Puccinia sessilis*, from which it differs in having yellow uredospores and in the teleutospores being surrounded by a dark brown bed of tissue. The two *Pucciniæ* otherwise so closely resemble each other as to be practically indistinguishable. Subjoined is a tabular summary of the cultures made to establish this.

No.	Infecting material.	Plant infected.	Date of infection.	Date of first result.
482.	*Puccinia Phalaridis.*	*Arum maculatum.*	25 April	6 May
483.	,, ,,	,, ,,	,,	7 May
484.	,, ,,	,, ,,	,,	10 May
485.	,, ,,	,, ,,	,,	11 May
486.	,, ,,	,, ,,	,,	10 May
487.	,, ,,	,, ,,	,,	,,
488.	,, ,,	,, ,,	,,	11 May
598.	,, ,,	,, ,,	30 April	15 May
600.	,, ,,	,, ,,	,,	20 May
510.	*Æcidium Ari.*	*Phalaris arundinacea.*	2 May	12 May
557.	,, ,,	,, ,,	29 May	16 June
558.	,, ,,	,, ,,	,,	,,
559.	,, ,,	,, ,,	,,	,,
560.	,, ,,	,, ,,	,,	,,
561.	,, ,,	,, ,,	,,	,,
562.	,, ,,	,, ,,	,,	,,
563.	,, ,,	,, ,,	,,	,,
564.	,, ,,	,, ,,	,,	,,
565.	,, ,,	,, ,,	,,	,,
566.	,, ,,	,, ,,	,,	20 June
567.	,, ,,	,, ,,	,,	,,
503. }	*Puccinia Phalaridis.*	*Allium ursinum.*	25 April	
504. }	,, ,,	*Arum maculatum.*	,,	11 May
104.	,, ,,	*Allium ursinum.*	26 Feb.	——
129.	,, ,,	,, ,,	1 May	——
157.	,, ,,	,, ,,	29 May	——

PUCCINIA ARENARIICOLA, n. sp.; soris parvis, nigris, nudis, linearibus vel elongatis, plerumque hypophyllis; sporis longos pedicellos præditis, lævibus, nullis, oblongisve cuneiformibus.

I. *Æcidiospores.*—Spots circular on the leaves, elongated on the stems, yellow, surrounded by a purple margin. Cups mostly hypophyllous, rarely epiphyllous, edges whitish, prominent, torn, everted. Spores subspherical or polygonal, smooth, yellow, 15 to 20 mk.

II. *Uredospores.*—Sori brown, erumpent, linear or oblong, about ·5 mill. long, surrounded by the torn epidermis, seated on yellowish spots. Spores globose or suboval, brown, finely echinulate, 18 to 20 mk.

III. *Teleutospores.*—Sori small, black, naked, linear or elongated, mostly hypophyllous. Spores on long pedicels, smooth, dark brown, oblong or cuneiform. The upper cell usually darker, rounded and thickened above; lower cell somewhat attenuated, constriction not very marked; 40 to 50 mk. long, by 20 mk. wide.

I. On *Centaurea nigra*, L. II. and III. On *Carex arenaria*, L.

On the sea-shore, Hemsby, Norfolk.

The Carices as a family are the hosts of many species of *Pucciniæ*. Thus in Europe they harbour *Puccinia Caricis*, Schum., *P. limosæ*, Magnus, *P. sylvaticæ*, Schröt., *P. microsora*, Körn., *P. caricicola*, Fckl., *P. vulpina*, Schröt., *P. dioica*, Magnus, and *P. Schœleriana*, Plow.

In this country we have *P. Caricis*, Schum., upon *Carex hirta*, *C. riparia*, and probably other species; and *P. Schœleriana*, Plow., on *Carex arenaria*. This last-named species is, so far as at present known, confined to *C. arenaria*. Its life-history has been already worked out by a series of experimental cultures, which established its distinctness from *P. Caricis*. It has its æcidiospores upon *Senecio Jacobæa* (*Æcidium Jacobææ*, Grev.). The details of these cultures have been published elsewhere *.

In the summer of 1884, the Rev. Canon Du Port sent me a leaf of *Centaurea nigra* affected by a fine *Æcidium*, which he had gathered on the sea-shore at Hemsby, on the Norfolk coast. No record of an *Æcidium* on this host-plant being known to me, I was much interested in its life-history. De Candolle †, it is true, has described an *Æcidium* on *Centaurea Cyanus*, but this is clearly not the fungus in question. In July 1884 a visit was made to Hemsby and a number of specimens collected. *Centaurea nigra* is very frequently affected with a *Uredo* and *Puccinia*; but always, hitherto, these spore-forms have been unaccompanied by any *Æcidium*. Hence the presumption was that the Hemsby *Æcidium* was unconnected with the above *Puccinia*, and that it was an heterœcious species. A careful examination of the Hemsby *Centaureæ* failed to disclose any *Uredo* or *Puccinia* upon them, although the *Æcidium* was abundant in all stages. An examination of the surrounding Grasses and Carices failed also, at this time, in throwing any light upon the subject. On 14th August, 1884, another journey was made to the spot, which was more successful. No *Uredo* or *Puccinia* could be found on the *Centaurea*; but upon *Carex arenaria*, which grew in the immediate vicinity, a *Uredo* and *Puccinia* were abundant.

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* Plowright, "On the Life-History of certain British Heterœcismal Uredines," Quart. Journal of Micro. Science, n. s. vol. xxv. pp. 167–170.

† De Candolle, Flora Franç. vol. v. p. 90.

This *Puccinia* differed from *P. Schœleriana* in its smaller sori and in its uredo-sori causing much less discoloration of the affected leaves. Specimens of the *Puccinia* were carefully preserved during the winter under such conditions as I had previously found most likely to ensure free germination in the following spring*. Towards the end of March (1885), the *Puccinia*-spores began to germinate; and on 31st March a number of freely germinating spores were placed upon the unfolded leaves of a plant of *Centaurea nigra*. It was not until the 21st April, however, that the *Æcidium* showed unequivocal signs of its appearance. This long period of incubation on the part of the parasite is quite in accordance with my previous experience of cultures made during the colder seasons of the year. The next culture was on the 8th April, when nine separate plants of *Centaurea* were infected with the *Puccinia*, on all of which the *Æcidium* had begun to appear in ten days. Similar cultures were made on 12th May, 1885, and 24th May, 1886, all of which were followed by the same result.

The converse cultures, of placing the æcidiospores from the *Centaurea* on *Carex arenaria*, were made on the 12th and 15th of May, and were equally successful, the *Uredo* appearing on the 29th May and 6th June respectively. In due course the *Uredo* was followed by the *Puccinia*. Further, these pucciniospores of 1885 again gave origin to the *Æcidium* in 1886. It was, however, further necessary to establish the distinction of *Puccinia arenariicola* from the other two British *Carex*-affecting *Pucciniæ*—*P. Caricis* and (especially) *P. Schœleriana*, the latter occurring on *C. arenaria*.

With this object several duplicated cultures were made in the following manner:—A quantity of the spores of *P. arenariicola* were germinated in a watch-glass, one half of which were placed on a plant of *Centaurea nigra*, and the other half on a plant of *Senecio Jacobæa*: the former gave rise to the *Æcidium*, the latter did not. A converse duplicated culture was, in the same manner, made with the spores of *P. Schœleriana*, one half of which were placed on *Senecio Jacobæa* and the other half on *Centaurea nigra*: the former gave rise to the *Æcidium*, the latter did not.

Similar duplicated cultures were made with *P. arenariicola* on *Urtica dioica* and *Centaurea nigra*: the latter was successful, and the former not. Conversely, *P. Caricis* from *C. hirta* gave rise to the *Æcidium Urticæ*, but not to the *Æcidium* on *Centaurea.*

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* For the benefit of those botanists who are interested in this subject, I purpose at an early date to give a detailed account of the *modus operandi* of performing these uredine cultures.

It was thus conclusively demonstrated that *P. arenariicola* is distinct from both *P. Caricis* and *P. Schœleriana.*

Subjoined is a tabular summary of the cultures made, the duplicated experiments being bracketed together:—

PUCCINIA ARENARIICOLA.

No.	Infecting material.	Plant infected.	Date of infection.	Date of first result.
466.	*Puccinia arenariicola.*	*Centaurea nigra.*	31 March	21 April
477.	,, ,,	,, ,,	8 April	18 April
478.	,, ,,	,, ,,	,,	,,
479.	,, ,,	,, ,,	,,	,,
480.	,, ,,	,, ,,	,,	,,
530.	,, ,,	,, ,,	12 May	29 May
633.	,, ,,	,, ,,	24 May	6 June
529.	*Æcidium Centauriæ.*	*Carex arenaria.*	12 May	29 May
537.	,, ,,	,, ,,	15 May	6 June
501.	*Puccinia Schœleriana.*	*Senecio Jacobæa.*	25 April	11 May
502.	,, ,,	*Centaurea nigra.*	,,	——
447.	,, ,,	*Senecio Jacobæa.*	15 Sept.	26 Sept.
447*	,, ,,	*Centaurea nigra.*	,,	——
467.	*Puccinia arenariicola.*	,, ,,	8 April	18 April
468.	,, ,,	*Senecio Jacobæa.*	,,	——
508.	*Puccinia Caricis.*	*Centaurea nigra.*	1 May	——
509.	,, ,,	*Urtica dioica.*	,,	18 May
531.	*Puccinia arenariicola.*	*Centaurea nigra.*	12 May	29 May
532.	,, ,,	*Urtica dioica.*	,,	——

THE GYMNOSPORANGIA.

It has hitherto been generally accepted that in Europe we have three species of *Gymnosporangium* which have their three corresponding æcidiospores or Rœsteliæ, namely:—

1. *G. clavariæforme* = *R. lacerata*, on *Cratægus Oxyacantha.*
2. *G. juniperinum* = *R. cornuta*, on *Pyrus Aucuparia.*
3. *G. fuscum* = *R. cancellata*, on *Pyrus communis.*

In May 1882, however, some cultures were made with these *Gymnosporangia* which gave certain unexpected results, inasmuch as they showed that the æcidiospores were not confined to the three host-plants above named. It was found that *G. clavariæforme* was capable of producing æcidiospores on *Pyrus communis* as well as upon *Cratægus Oxyacantha*, and that *G. Sabinæ* could give rise to a *Rœstelia* on *Cratægus Oxyacantha* as well as upon *Pyrus communis.* The life-history of the *Gymnosporangia* therefore is not so simple a matter as the experiments of Œrsted would lead us to suppose. From the frequency with which Œrsted's experiments have been repeated by continental botanists, it was remarkable that the above facts had not been already made known; and it became necessary, before the results of my experiments were published, that they should be confirmed by a considerable number of observations. Since 1881 some 90 experimental cultures have been made with these Fungi, so that it cannot be alleged that my conclusions have been hurriedly made upon insufficient data. During the year 1882 Rathay * published the results of a series of cultures made by him with the *Gymnosporangia*, which are subjoined in a tabular form. It will be seen at a glance that these Uredines have their æcidiospores upon a number of host-plants, and that the original statements of Œrsted concerning them require a certain amount of modification.

Rathay's Experimental Cultures with the Gymnosporangia.

Positive Results.

Teleutospores.	*Æcidiospores on*
Gymnosporangium fuscum, *DC.* (*Tremella Sabinæ*, Dicks.)	Pyrus communis.
Gymnosporangium juniperinum, *Fr.* (*Tremella juniperina*, L.)	P. Aucuparia. P. Aria. Amelanchier vulgaris. Pyrus Malus. P. vulgaris.
Gymnosporangium clavariæforme, *DC.* (*Tremella clavariæformis*, Jacq.)	P. torminalis. P. communis. Cratægus Oxyacantha. C. monogyna.

Negative Results.

Gymnosporangium fuscum, *DC.*	Mespilus germanica. Cratægus Oxyacantha. C. monogyna. Pyrus Malus. P. Aria. P. torminalis.
Gymnosporangium juniperinum, *Fr.*	Mespilus germanica. Cratægus Oxyacantha. C. monogyna. Pyrus domestica. P. torminalis.
Gymnosporangium clavariæforme, *DC.*	Mespilus germanica. Pyrus Malus. P. domestica. P. Aria.

From which it appears that Rathay was unable to discover which of the *Gymnosporangia* produced the *Ræstelia* on *Mespilus*

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* Rathay, 'Untersuchungen über die Spermogonien der Rostpilze,' Wien, 1882, pp. 20–22.

germanica, nor did he obtain any result with *G. fuscum* except upon *Pyrus communis*.

Gymnosporangium clavariæforme, DC.

In 16 separate experiments in which I placed the spores of *G. clavariæforme* on *Cratægus Oxyacantha*, the *Rœstelia* was in every case produced. Such an unbroken series of successful cultures is, to say the least of it, remarkable, for in the ordinary course of events one expects a certain percentage of failures from accidental circumstances. It is evident, however, that this *Gymnosporangium* very readily attacks *C. Oxyacantha*. On the other hand, in 7 cultures with this *Gymnosporangium* on *Pyrus communis*, only two were successful (Exp. 24 and 344). The *Rœstelia* thus produced on *Pyrus* is clearly distinct from that known as *R. cancellata* (from *G. fuscum*) in the form of its peridia, &c. With *G. clavariæforme* on *Pyrus Malus* and *P. Aucuparia*, in the limited number of cultures made, no result was obtained.

The converse culture of the *Rœstelia* on *Juniperus communis* is one that does not seem to have been often made, or, if made, the results are unrecorded. Hence the details of my experiments are appended.

Exp. 410. A small seedling Juniper, about an inch in height and one year old, was on the 25th June, 1884, freely infected with the spores of *Rœstelia lacerata*. On 1st July it was evident that the infection had been successful from the fact that a number of the leaves of the Juniper were turned yellow in places. These leaves during the autumn fell off. During the following year (1885) the base of the stem began to swell; to such an extent did this swelling of the stem go, that the plant was killed by it during the winter of 1885–86.

Exp. 411. Two healthy Junipers about a foot high were planted side by side in 1883. They showed no sign of being affected with the *Gymnosporangium*. On 25th June, 1884, one of them was infected freely with the spores of *R. lacerata*, the other being covered by a large bell-glass to prevent accidental inoculation. On the 8th July many of the younger leaves began to turn yellow; these during the summer and autumn fell off; so that in the spring and summer of the following year (1885) the infected plant had such a peculiar habit of growth that a casual observer could not fail to notice the contrast between it and the control plant. In December 1885 the bare places on the branches from which the infected leaves had fallen showed marked swellings; these continued to increase; and from them on 1st April, 1886, were developed the characteristic *Gymnosporangium clavariæforme*. Thus it is evident that two years are required for the development of the *Gymnosporangium* from the time the *Ræstelia*-spores enter the leaves until the teleutospores are produced.

GYMNOSPORANGIUM CLAVARIÆFORME.

No.	Infecting material.	Plant infected.	Date of infection.	Date of first result.
4.	*G. clavariæforme.*	*Cratægus Oxyacantha.*	6 April	24 April
5.	„ „	„ „	7 April	„
15.	„ „	„ „	17 April	6 May
27.	„ „	„ „	11 May	21 May
161.	„ „	„ „	2 June	11 June
316.	„ „	„ „	24 April	10 May
317.	„ „	„ „	„	„
318.	„ „	„ „	„	„
319.	„ „	„ „	„	„
320.	„ „	„ „	„	„
349.	„ „	„ „	16 May	29 May
376.	„ „	„ „	28 May	7 June
491.	„ „	„ „	25 April	5 May
492.	„ „	„ „	„	10 May
628.	„ „	„ „	18 May	29 May
639.	„ „	„ „	9 June	24 June
410.	*Ræstelia lacerata.*	*Juniperus communis.*	25 June	1 July
411.	„ „	„ „	„	8 July
24.	*G. clavariæforme.*	*Pyrus communis.*	10 May	3 June
28.	„ „	„ „	11 May	——
160.	„ „	„ „	2 June	——
344.	„ „	„ „	16 May	27 May
490.	„ „	„ „	25 April	——
640.	„ „	„ „	9 June	——
641.	„ „	„ „	„	——
345.	„ „	*Pyrus Malus.*	16 May	——
348.	„ „	*P. Aucuparia.*	„	——

Gymnosporangium juniperinum, Fr.

This fungus does not occur near King's Lynn. I have to thank my friends the Rev. Dr. Keith, of Forres, and the Rev. John Stevenson, of Glamis, for sending me material from Scotland. Had the fungus occurred nearer, more experiments would have been made with it, and most likely with a greater degree of success.

In 7 experiments the *Gymnosporangium* was placed on *Pyrus Aucuparia*, and in five the *Ræstelia* was produced. In some of these experiments more than one *Sorbus*-plant was infected; in one instance, in which the *Ræstelia* was abundant upon the leaves in the autumn of 1882, I observed in the following April a single leaf bearing spermogonia. This is the only case in all my cultures in which the æcidial mycelium did not perish during the winter. Unfortunately the spermogonia were employed for another experiment, so that it is uncertain whether the *Ræstelia* would have been subsequently developed. It is most likely that a bud was infected by one of the promycelial spores, as the experiment was made rather late in the summer of the preceding year.

Three experiments with *G. juniperinum* on *Pyrus Malus* and one on *Pyrus vulgaris* were without result.

GYMNOSPORANGIUM JUNIPERINUM.

No.	Infecting material.	Plant infected.	Date of infection.	Date of first result.
43.	*G. juniperinum.*	*Sorbus Aucuparia.*	29 May	25 June
44.	" "	" "	"	21 June
45.	" "	" "	"	——
63.	" "	" "	12 June	16 August
73.	" "	" "	18 June	1 July
408.	" "	" "	23 June	——
409.	" "	" "	"	2 July
407.	" "	*Pyrus Malus.*	22 June	——
426.	" "	" "	7 July	——
429.	" "	" "	8 July	——
430.	" "	*P. vulgaris.*	"	——

Gymnosporangium fuscum, DC.

It has hitherto been generally accepted that this *Gymnosporangium* has its æcidiospores exclusively confined to *Pyrus communis*, as was originally demonstrated by Œrsted. The experiments of Rathay also tend to confirm this, as he was unable to produce any æcidiospores for this *Gymnosporangium* upon the six last plants previously enumerated in the table of his negative results. In some cultures which I made in May 1882, however, I found that *G. fuscum* was capable with me of giving rise to æcidiospores upon *Cratægus Oxyacantha*. At the time I regarded this result as possibly arising from some accidental admixture of foreign spores; and before venturing to publish results at variance with preceding investigation I considered it necessary that my cultures should be many times repeated. In my investigations into the life-history of *G. fuscum*, 53 separate cultures have been made. In 30 cases *G. fuscum* was placed on *Cratægus Oxyacantha*, 86 per cent. of which were followed by the appearance and development of a *Ræstelia*. There can be no question therefore that *G. fuscum*, as it occurs in this neighbourhood, has æcidiospores upon Hawthorn, which result was obtained 26 times out of 30. The question presents itself, Are there two species of *Gymnosporangium* upon *Juniperus Sabinæ*, as there are upon *J. communis*? Simple as this question appears to be, it is by no means so easy to answer it. Had this been the case, I should not have needed to perform 53 cultures.

In the first place, Does the *Ræstelia* on *Cratægus* produced from *G. fuscum* differ from the *Ræstelia* from *G. clavariæforme*? It is important to settle this point, because it might be alleged that these two *Gymnosporangia* were the same plant, differing only from each other in such particulars as may be due to the differences of their respective host-plants. The *Ræstelia* on *Cratægus* from *G. fuscum* differs from that of *G. clavariæforme* in the following points :—(1) the spermogonia are produced on more brightly coloured spots; (2) the spores are rather smaller; (3) the cells of the pseudoperidia are marked with delicate reticulations or longitudinal wrinkles, whereas those of *G. clavariæforme* are dotted with minute elevated points.

With regard to *G. fuscum*, Körnicke *, several years ago, pointed out that the fungus as he found it near Königsberg differed very materially from the description given by De Candolle †. In Körnicke's plant the masses were thin and gelatinous, and dried upon the branches in thin laminæ; whereas De Candolle speaks of his plant as being but little gelatinous, having a velvety exterior, and when broken in the dry state, the interior is white and cottony. But even this does not help us, for the plant, as I find it here, answers while young to De Candolle's description, and when old, especially in rainy weather, it agrees with Körnicke's. Still I am of opinion that there are two species of *Gymnosporangia* in *G. fuscum*, although, up to the present, I have been quite unable to separate them.

With regard to the cultures of *G. fuscum* on *Pyrus communis*, 19 experiments have been made, of which 13 were successful, while 6 failed. This large proportion of failures looks very much as if there was a second species which does not have its æcidiospores on *Pyrus*. Furthermore, in my earlier cultures made in 1882–83, I had a larger proportion of successes than I have had since that date. My earlier cultures were principally made with material from a Sabine bush which died in 1884. It must be remembered, however, that, as Reess* pointed out in 1870, *G. fuscum* has two forms of teleutospore, one much darker in colour than the other and less abundant. I find these two spore-forms constantly mixed together in the same jelly-masses, and that the paler spores germinate at once upon being placed in water, but that the darker ones do not. *G. fuscum* gave rise, in Exp. 522, to the *Ræstelia* on *Mespilus germanica*; but, owing to the difficulty of obtaining suitable *Mespilus*-plants, I have not been able to repeat the experiment.

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* Körnicke, 'Hedwigia,' 1877, p. 25.

† De Candolle, Flor. Franç. vol. ii. p. 217.

With *Pyrus Malus* and *Pyrus Aucuparia*, in the small number of cultures I have made, my results, like those of previous observers, have been negative.

Unsatisfactory as these observations are from one point of view, yet it is desirable that they should be put upon record. Prof. Farlow, who is engaged upon the study of the life-history of the American *Gymnosporangia*, which species are far more numerous there than is the case in Europe, has also found it exceedingly difficult, so that I have the less compunction in publishing the results of my own observations.

GYMNOSPORANGIUM FUSCUM.

No.	Infecting material.	Plant infected.	Date of infection.	Date of first result.
2.	*Gymnospor. fuscum.*	*Pyrus communis.*	19 April	6 May
6.	” ”	” ”	7 April	24 April
10.	” ”	” ”	14 April	6 May
25.	” ”	” ”	11 May	11 June
126.	” ”	” ”	29 April	—
127.	” ”	” ”	”	—
185.	” ”	” ”	12 June	2 July
186.	” ”	” ”	”	”
507.	” ”	” ”	30 April	—
535.	” ”	” ”	12 May	—
569.	” ”	” ”	3 June	—
353.	” ”	” ”	18 May	—
354.	” ”	*Cratægus Oxyacantha.*	”	1 June
355.	” ”	” ”	”	7 June
356.	” ”	*Pyrus Malus.*	”	—
357.	” ”	*P. Aucuparia.*	”	—
493.	” ”	*Cratægus Oxyacantha.*	25 April	7 May
494.	” ”	” ”	”	5 May
495.	” ”	” ”	”	10 May
496.	” ”	*Pyrus communis.*	”	—
591.	” ”	*Cratægus Oxyacantha.*	29 April	7 May
592.	” ”	*Pyrus communis.*	”	—
593.	” ”	*Cratægus Oxyacantha.*	30 April	9 May
594.	” ”	*Pyrus communis.*	”	—

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* Reess, Abh. d. naturf. Ges. zu Halle, 1870, p. 65.

GYMNOSPORANGIUM FUSCUM (*continued*).

No.	Infecting material.	Plant infected.	Date of infection.	Date of first result.
606.	*Gymnospor. fuscum.*	*Pyrus communis.*	1 May	
607.	,, ,,	*Cratægus Oxyacantha.*	,,	10 May
618.	,, ,,	,, ,,	11 May	23 May
619.	,, ,,	*Pyrus communis.*	,,	30 May
624.	,, ,,	*Cratægus Oxyacantha.*	18 May	1 June
625.	,, ,,	*Pyrus communis.*	,,	——
626.	,, ,,	*Cratægus Oxyacantha.*	18 May	——
627.	,, ,,	*Pyrus communis.*	,,	——
629.	,, ,,	*Cratægus Oxyacantha.*	18 May	29 May
630.	,, ,,	,, ,,	,,	28 May
631.	,, ,,	,, ,,	,,	29 May
632.	,, ,,	,, ,,	,,	31 May
22.	,, ,,	,, ,,	10 May	20 May
23.	,, ,,	,, ,,	,,	,,
26.	,, ,,	,, ,,	11 May	4 June
41.	,, ,,	,, ,,	25 May	11 June
125.	,, ,,	,, ,,	24 April	——
159.	,, ,,	,, ,,	2 June	——
523.	,, ,,	,, ,,	7 May	17 May
524.	,, ,,	,, ,,	,,	,,
525.	,, ,,	,, ,,	,,	,,
526.	,, ,,	,, ,,	,,	,,
527.	,, ,,	,, ,,	,,	,,
528.	,, ,,	,, ,,	,,	,,
534.	,, ,,	,, ,,	12 May	24 May
570.	,, ,,	,, ,,	3 June	——
506.	,, ,,	,, ,,	28 April	19 May
186*.	,, ,,	*Pyrus Malus.*	12 June	——
522.	,, ,,	*Mespilus germanica.*	7 May	20 May

Analysis of 91 *Experimental Cultures with the Gymnosporangia.*

No. of Exps.	Infecting material.	Plant infected.	Successes.	Failures.
19.	*Gymn. fuscum.*	*Pyrus communis.*	13	6
30.	,, ,,	*Cratægus Oxyacantha.*	26	4
1.	,, ,,	*Mespilus germanica.*	1	
2.	,, ,,	*Pyrus Malus.*	...	2
1.	,, ,,	*R. Aucuparia.*	...	1
16.	*Gymn. clavariæforme.*	*Cratægus Oxyacantha.*	16	
7.	,, ,,	*Pyrus communis.*	2	5
1.	,, ,,	*P. Malus.*	...	1
1.	,, ,,	*P. Aucuparia.*	...	1
7.	*Gymn. juniperinum.*	,, ,,	5	2
3.	,, ,,	*P. Malus.*	...	3
1.	,, ,,	*P. vulgaris.*	...	1
2.	*Ræstelia lacerata.*	*Juniperus communis.*	2	

The Gentians: Notes and Queries.

By T. H. Huxley, F.R.S., F.L.S.

[Read 7th April, 1887.]

(Plate II.)

I happened to spend some six weeks, from the end of July to the beginning of September 1886, at *Arolla* (a locality situated at the head of one of the southern offshoots of the valley of he Rhone near Sion), 6400 feet above the level of the sea. During my wanderings about the woods and pastures which clothe the sides of the valley from this level to the snow-line, a couple of thousand feet higher, my attention was attracted by the characteristically alpine vegetation, and more especially by the Gentians, of which some species, such as *Gentiana purpurea* and *G. campestris*, were very abundant. *G. verna* and *G. acaulis* were also by no means uncommon; but the latter had almost ceased to flower.

It is well-nigh forty years since I occupied myself with systematic botany; and I had no works of reference at hand except Gremli's 'Flore analytique,' which I happened to have bought at Lausanne, and Rapin's 'Guide des Botanistes dans le Canton de Vaud,' which a fellow-traveller was kind enough to lend me. But the extraordinary amount of variation which presented itself when I compared considerable suites of specimens with the diagnoses and descriptions in these works struck me so much that, all "unanointed and unannealed" as I was in systematic work, I was tempted to see what I could make out of the facts for myself. In truth, the Gentians took hold of me rather than I of them; and I have been more or less their bondservant ever since. Beginning with *Gentiana purpurea*, I found that I could not understand that form without knowing something about the rest of the species of *Gentiana*; and, by a parity of reasoning, a knowledge of *Gentiana* involved that of the other genera of the Gentianeæ. So that, since my return to England, I have been led to make a rapid survey of the whole Order; and it is the broad results of that survey that I wish to lay before the Linnean Society.

I have to thank the Director of Kew Gardens for the free use of the splendid herbarium under his charge. It affords the means of carrying out the investigation I have attempted much more thoroughly; and I am well aware of the incompleteness of the observations I venture to offer. But, at present, it is needful for me to turn my attention to other things; and if I venture to bring forward so imperfect a piece of work, it is in the hope that it may be taken up and finished by more competent hands.

Every botanist is aware that the Gentianeæ constitute one of the most natural and well-defined of the Orders of plants. The type of structure which runs through the five or six hundred species included in the Order undergoes but few and, for the most part, inconsiderable modifications. There are no trees and but few shrubs among them; a few are climbers; and there are a few saprophytes. The opposition, entirety, and palmati-venation of the leaves have but few exceptions; and it is very rarely that the flower departs from typical regularity. The chief distinctive characters of the groups into which the Order is at present divided lie in the flower, and indeed in the corolla; since the form and proportion of the calyx, the occasional synanthery, and the greater or less intrusion of the placentæ are characters which vary greatly from genus to genus.

Under these circumstances, I have confined myself almost entirely to the study of the structure of the flower. I find that some seven or eight modifications of that structure are distinguishable; and that these again fall into two series, each of which is characterized by a peculiar disposition of the nectarial organs, and presents a gradation of forms of the corolla from the rotate, or rather stellate, condition, through the campanulate to the extreme infundibulate character.

In one of these series the nectarial cells are situated on the inner surface of the cup, from the edge of which the lobes of the corolla proceed, and towards its basal end. They are aggregated in such a manner as to form either a single patch, bisected by the vein which becomes the median vein of a corolla-lobe; or two patches, one on each side of that vein. I term the Gentianeæ of this series *Perimelitæ*.

In the other series there are no such patches of secreting-cells visible on the corolla; but in many members of the series there is a zone of such cells, which encircles the base of the ovary, and is therefore furnished by the outer faces of the carpellary phyllomes, which are often raised into tubercles. In others, I have not been able to make sure of the existence of nectarial cells, either on the surface of the ovary or on the stemono-carpellary internode, which forms the actual bottom of the flower-cup. But dried plants are very unfavourable subjects for the determination of points of this kind; and as many of these flowers, which have no apparent nectaries, are known to be visited by honey-sucking insects, I shall for the present assume that honey-secreting surfaces exist on the central parts of the flower. In contradistinction to the *Perimelitæ*, the Gentianeæ of this series may be termed *Mesomelitæ*.

In the series of the *Perimelitæ* four modifications of floral structure are discernible. To these I propose to give the names of *Actinanthe*, *Keratanthe*, *Lophanthe*, and *Stephananthe*.

I. *Actinanthe.*

The corolla is rotate*, or, if it is more or less campanulate, the sinuses which separate the lobes are very deep. The nectarial areæ are single or double, and often concave inwardly. There is no distinct gynophore; but the ovary is occasionally "stipitate;" that is to say, its basal moiety, which then contains no ovules and remains very narrow, constitutes an apparent stalk on which the dilated ovuligerous moiety is supported. The margins of the lobes of the corolla may be produced into longer or shorter denticulations or laciniæ; but there are no filamentous appendages developed on the inner face of the corolla. The stigmatic surfaces are oblong-ovate.

The species in which I have found this type of floral structure are:—

A.
Gentiana
  aurea.
  umbellata.
  Moocroftiana.
  detonsa.

Jæschkea.
Pleurogyne.
Exadenus.

B.
Gentiana
  primulæfolia.
  vaginalis.
  nummularifolia.
  saxicola.
  multicaulis.
  incurva.
  Grisebachii.
  gracilis.
  monieroides.
  ericoides.
  magellanica.
  patagonica.

E.
Gentiana
  saxosa.
  cerina.

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* This term appears to me to be often employed ambiguously. It is applied, on the one hand, to corollæ in which the cup appears to be formed merely by the confluence or connation of the bases of the lobes, and is not in any way marked off from the latter; and, on the other hand, to corollæ in

In *Exadenus* the nectarial surfaces are hemispherically depressed and bulge outwards, so that their positions are marked externally by convexities of the corolla. Dr. Grisebach (‘Genera et Species Gentianearum,’ p. 322) says of each “fovea glandulifera,” that it is “extus tantum conspicua, intus per petali substantiam clausa;” but the real state of the case appears to me to be as I have stated it. *Exadenus*, in fact, represents the first stage of a transition from *Actinanthe* to the next type.

II. *Keratanthe.*

This differs from the preceding in no essential respect, except in the deepening of the nectarial concavities, in such a manner that their external walls project as long horns or spurs, which are sometimes directed downwards and sometimes upwards. Moreover, the lobes are relatively shorter, and the corolla is more or less campanulate. It is very possible, and indeed probable, that further inquiry may bring to light forms constituting a complete transition between *Actinanthe* and *Keratanthe.*

The genus *Halenia* is the only representative of this type.

III. *Lophanthe.*

Here, again, the corolla has fundamentally the same characters as in *Actinanthe*; and the only essential difference lies in the development of filamentous appendages, or fimbriæ, from the inner surface of its cup. These fimbriæ occur in different positions: sometimes they are *parastemonal*; that is to say, they arise singly or in groups from a common base, along, or close to, the line of symphysis of the filaments of the stamens with the cup of the corolla. In this case they are sometimes so minute as to be distinguishable only by the aid of the microscope; sometimes, on the other hand, they are so long as to extend across the interval between one series and another, and thus to form a more or less complete barrier across the interval between the ovary and the corolla. These fimbriæ have already been noticed in some of the species in which they occur; but

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which the cup more or less closely embraces the ovary, and is even narrower at the summit than the middle. The physiological import of the two forms is very different; and, morphologically, the latter are really hypocrateriform corollæ with very long lobes. I use the term “rotate” in the first sense.

they have been described as appendages of the filaments of the stamens. I have looked into this point with considerable care; and, in all cases, I find that the fimbriæ cohere with the corolla and not with the filaments, if sufficient care is taken in separating the two. If the filaments are roughly torn away, on the other hand, some of the fimbriæ may come with them, attached by flakes of the corolline epidermis. In order to remove all possible doubt, it would of course be necessary to study the development of the fimbriæ.

In other exemplifications of the *Lophanthe* type the fimbriæ are *perinectarial*; that is to say, they are developed, not in longitudinal series parallel with and close to the stemono-petaline symphyses, but in close relation with the margins of the nectarial areæ.

The species in which I have met with the *Lophanthe* modification are:—

1. With *parastemonal* fimbriæ.

A.	B.	D.	E.
Gentiana	Gentiana	Gentiana	Gentiana
ciliata.	foliosa.	montana.	montana.
crinita.	rupicola.	diemensis.	concinna.
barbatula.	Hookeri.	pleurogynoides.	
	fastigiata.		
	cerastioides.		
	cernua.		
	Jamesonii.		
	radicata.		
	limoselloides.		
	diffusa.		

2. With *perinectarial* fimbriæ.

Swertia (Ophelia).
Frasera.

The fimbriæ of *Swertia* and *Frasera* are well known. In the *Gentianæ* proper the only distinct account of them which I have met with is that given by Müller ('Alpenblumen,' p. 343, *G. ciliata*). The disposition of the fimbriæ in the various species in which they occur is well worthy of a more careful and detailed study than it has yet received. In some species (e. g. *Gentiana montana*, *pleurogynoides*, and *rupicola*) the parastemonal fimbriæ are so minute as to suggest that they may be absent in some varieties, which would thus effect a transition between *Lophanthe* and *Actinanthe*. Sir J. Hooker ('Flora of New Zealand') has already suggested that *G. concinna*, *saxosa*, and *pleurogynoides* may be varieties of *G. montana*. Perhaps it may be as well to mention that the mycelia of fungi, not infrequent in dried flowers, occasionally resemble fimbriæ.

IV. *Stephananthe.*

The corolla is elongated, campanulate, or infundibulate; the relatively short lobes becoming deflexed at right angles to the elongated "cup" in the fully expanded flower. Just below the junction of each lobe with the cup, the inner wall of the corolla is produced into a transverse ridge, the free, slightly convex, edge of which becomes divided into a number of broad flat unequal lobes, and these, again, subdivide into approximately equal, flat, elongated and pointed pectinations. The longitudinal axis of these (in the species which I have examined) is traversed by a vascular bundle derived from the veins of the corolla; and, in this respect, they differ from the fimbriæ of *Lophanthe*, in which I have found no vascular bundles. For the sake of distinguishing them from the fimbriæ, I propose to call these structures, which constitute the well-known "corona," *pectines*.

It is easy to imagine that the *pectines* may have been derived from parastemonal fimbriæ, by the transverse extension of the upper ends of the two series of such fimbriæ until they met in the middle line, while the longitudinal part of each series became aborted; but I have met with no indication of the transitional forms between *Lophanthe* and *Stephananthe* which, on this hypothesis, must have existed. In *Frasera* there are transversely disposed rows of fimbriæ which have a certain, though not very close, resemblance to the pectines; but they are situated on the basal side of the nectaries and close to them, while the pectines are on the opposite side and far away from the nectaries. In the expanded flower, the pectines are directed upwards and inwards, sometimes more in the one direction, sometimes more in the other. It would be very interesting to ascertain whether their position does, or does not, vary according to the state of development of the pollen and the stigmatic surfaces.

The following species are referable to this type. Those marked with an asterisk are placed here on the authority of Grisebach or of Weddell.

A.
Gentiana
Amarella.
campestris.
germanica.
tenella.
*auriculata.
*nana.
*livonica.
*acuta.
*floribunda.
*mexicana.

B.
Gentiana
liniflora.
nitida.
*inflata.
*thyrsoidea.
*crassolæma.
*trichostemma.
*scopulosa.
*filamentosa.
*Ringii.

These are all the types of floral structure which I have met with in the Perimelitous series. It will be observed that, looking at them broadly, they present a general progress, so far as the shape of the corolla is concerned, from the stellate form with deeply divided lobes in, e. g., *G. aurea*, to the infundibulate form with sharply deflexed lobes in, e. g., *G. campestris*; and, so far as the difficulty of access to the nectaries is concerned, from the openness to all comers in the first case, to the hiding away at the end of horns in *Keratanthe*, the partial barring of the road in *Lophanthe*, and the more complete obstruction offered by the corona in *Stephananthe*.

In the series of the *Mesomelitæ* the following modifications have presented themselves:—

V. *Asteranthe*.

The corolla is rotate, the cup being very short and the lobes very long. There are no plicæ, fimbriæ, or other appendages, and the expanded flower is widely open.

I find this structure only in the genus *Eustoma* and in *Gentiana lutea*. I am unable to say anything definite about the nectarial surfaces in the former, except that there are none discoverable on the corolla. In the latter, they are well known to form a zone round the base of the ovary. Neither *Eustoma* nor *Gentiana lutea* are, theoretically speaking, satisfactory representatives of the least modified forms of the Mesomelitous series. For this purpose a Gentian with a flower like that of *G. saxosa*, but with the nectaries ovarian, is wanted; and I have not been able to find any which fulfils this requirement. In *Eustoma* the calyx and the ovary are specialized in the direction of the type which I shall describe under the head of *Lissanthe*; and in *Gentiana lutea* in the direction of *Ptychanthe.* The spathose calyx and the ovary of *Gentiana lutea* present points of strong resemblance to those of *G. purpurea*; and the free hybridization, under natural conditions, of the two last-mentioned species is asserted upon apparently strong evidence. In my opinion, however, that evidence is by no means so conclusive as it looks at first sight; and the facts of the case require careful and experimental re-examination.

It is of course possible that *G. lutea* may be an ally of *G. purpurea* which has reverted to a less modified condition; but at present I see no sufficient grounds for adopting that hypothesis.

VI. *Limnanthe.*

The corolla is rotate and devoid of nectaries. The margins of the lobes may be laciniated; or their surfaces may be beset with longitudinal rows of fimbriæ (*Menyanthes*). Five, apparently glandular "hypogynous" tubercles are commonly developed at the junction of the walls of the ovary with the perianthial cup, which is more or less adherent to the base of the ovary.

A.
Menyanthes.
Limnanthemum.

B.
Limnanthemum.

C.
Limnanthemum.
Villarsia.

D.
Liparophyllum.
Limnanthemum.
Villarsia.

E.
Liparophyllum.

All systematic botanists recognize the aberrant character of the *Menyantheæ.* But I do not find in the works which I have consulted any notice of the circumstance that some of them, at any rate, present a more or less marked perigyny. I have examined only *Limnanthemum indicum*, *Menyanthes trifoliata*, *Villarsia capensis*, and *Liparophyllum Gunnii*; but in all these the perianth adheres to the base of the ovary, and the adhesion becomes more and more extensive in the order in which the species have been named.

VII. *Lissanthe.*

The corolla is devoid of nectaries. Sometimes there are distinct, apparently nectarial, tubercles on the base of the ovary;

but, in the great majority, the presence or absence of nectarial surfaces has yet to be determined. Many are said to have "rotate" corollæ; but in all such which have come under my observation the corollæ are really hypocrateriform. Usually, the corolla varies from campanulate to long-tubed infundibulate forms; and the cup or tube is thin-walled, elastic, and pretty closely embraces the ovary. The filaments are inserted, sometimes very low down, and sometimes very high up in the tube. In some cases the anthers are united round the style, and the stigmas form a circular disk above the synantherous staminal ring (*Voyria*).

α. Corollæ short-tubed (hypocrateriform).

Lapithea, *Exacum*, *Chironia*, *Sabbatia*, *Dejanira*.

β. Corollæ long-tubed (infundibulate).

Chlora, *Erythræa*, *Canscora*, *Coutoubea*, *Prepusa*, *Lisianthus*, *Tachiadenus*, *Belmontia*, *Voyria*.

Here, as in preceding cases, the principle of the observed modification is obviously the interposition of obstacles in the way of access to the deep-seated portions of the cavity of the flower. In this respect, the flowers of *Voyria* and those of the long-tubed *Lisianthus* and *Tachiadenus* are models of obstructiveness.

I have examined species of the following genera:—

A.	B.	C.	D.	E.
Erythræa.	Erythræa.	Erythræa.	Erythræa.	Erythræa.
Chlora.				
Sabbatia.	Sabbatia.	Exacum.		
	Dejanira.	Sebæa.	Sebæa.	Sebæa.
	Coutoubea.	Belmontia.		
	Prepusa.	Tachiadenus.		
	Tachia.	Chironia.		
	Lisianthus.	Canscora.	Canscora.	
	Voyria.			

The nature of the cup-like "hypogynous disk" of some of the "Lisyantheæ" of Grisebach requires investigation. In the only species presenting this structure which I have examined, it appears to be formed by the coalescence of expansions of the bases of the filaments.

VIII. *Ptychanthe.*

The corolla is campanulate or infundibulate, never rotate. The wall of the tube, between the interlobular sinuses and the insertion of the filaments, is produced into a series of longitudinal plications or "interlobes," the folded edges of which project into the throat of the tube, and more or less completely divide it into a corresponding number of longitudinal passages. The free margins of the interlobes may extend as far as those of the lobes, and they may be provided with long laciniæ. In some species the anthers cohere into a ring round the style, below the stigma, which last may take the form of a disk. Very often, the stemono-corolline symphyses are produced into strong longitudinal ridges, which continue the direction of the interlobular folds, and, by abutting against the ovary, subdivide the basal moiety of the cavity of the flower into passages which continue those in its marginal half. The base of the ovary is often tuberculate and clearly nectarigenous. The basal portion of its cavity is often devoid of ovules; and, sometimes, is elongated into a narrow stipes, which, in certain cases (e. g. *Crawfurdia*), attains a great length.

This type of structure is found exclusively in those species of the genus *Gentiana* which are included by Grisebach under the heads of *Cœlanthe, Tretorhiza, Cyane, Chondrophyllum, Thylacites*; in some of the *Andicola*; and in the genus *Crawfurdia.*

I have specially examined the following out of the numerous species which exhibit this type of structure, several in the fresh state:—

A.
Gentiana
- verna.
- prostrata.
- squarrosa.
- asclepiadea.
- Andrewsii.
- affinis.
- acaulis.
- purpurea.
- Burseri.
- punctata.
- cruciata.
- nikoensis.
- Buergeri.
- Thunbergii.
- japonica.

Crawfurdia.

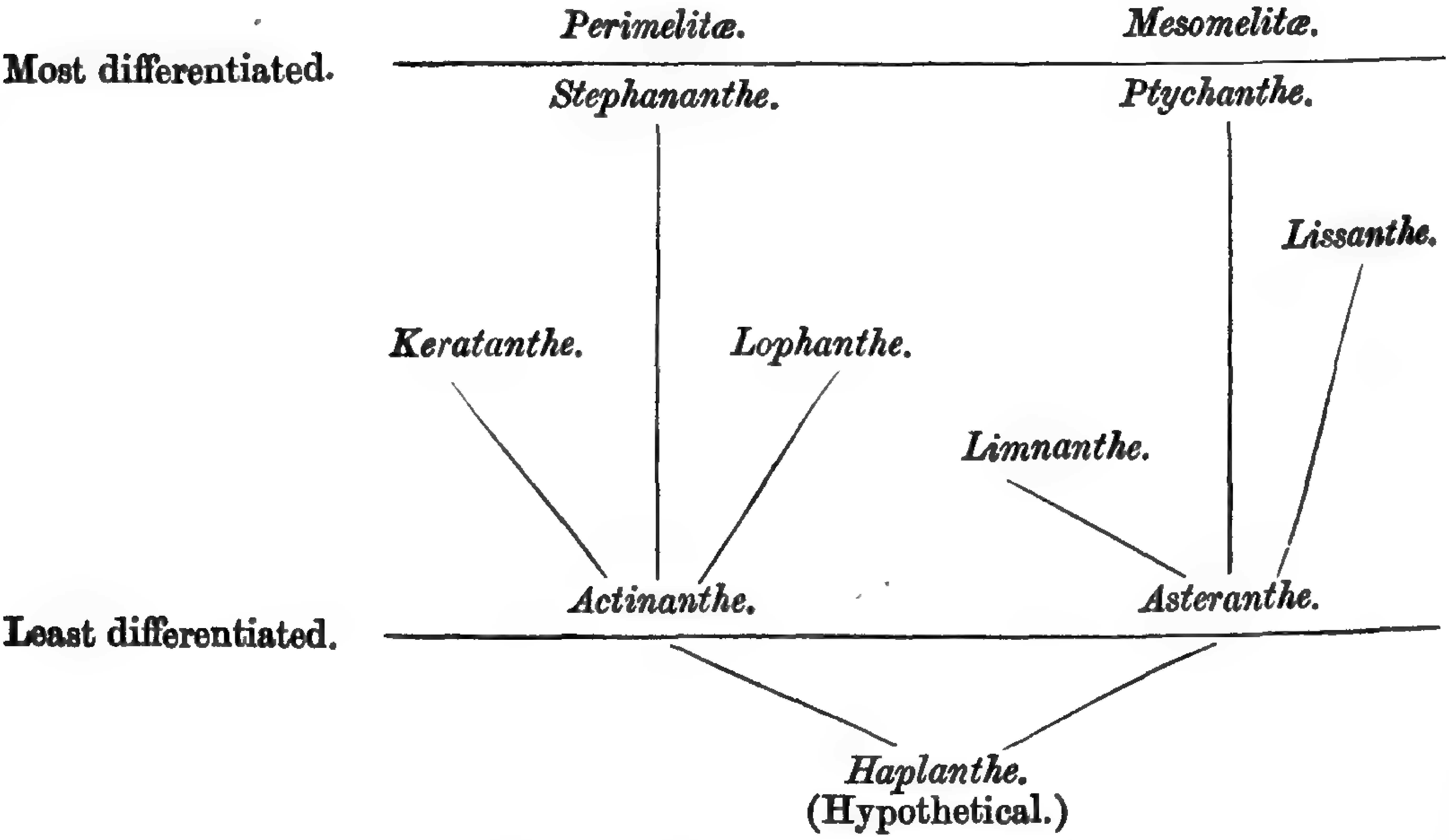
B.
Gentiana
- sedifolia.
- prostrata.
- spathacea.
- adsurgens.
- ramosissima.
- Gayi.

C.
Gentiana
- pedicellata.
- zeylanica.
- Loureirii.

Such are the types or leading modifications of floral structure which I have met with; and such the evidence, taken together with the extant descriptions of the forms I have not examined personally, on which I base the conclusion that they embrace all the most important morphological modifications of the corolla which the Gentianeæ offer. It will be observed that, unfortunately, they do not exhibit any particular relation to the received family, or even generic, groups. The accepted genus *Gentiana*, for example, exhibits no fewer than five of the eight types of floral structure; while the *Lissanthe* type is exhibited by some five-and-thirty accepted "genera." If *Frasera* and *Swertia* are to be regarded as generically distinct from *Gentiana*, I fail to see on what principle *G. amarella* and *G. purpurea*, which differ at least as much from one another as *Swertia*, *Frasera*, and *Gentiana* do, can be grouped into one genus. Considerations of this kind, which might be multiplied indefinitely, obviously suggest a thorough revision of the taxonomy of the Order—a task which I certainly shall not presume to attempt, but which will, I hope, be executed by some one more fitted to take such a large and difficult piece of work in hand.

Another important conclusion, which is naturally suggested by the facts to which I have drawn attention, is that the several types in each of the two series bear a certain progressive relation to one another. It is obvious that *Actinanthe* and *Asteranthe* are the simplest and least modified forms in each series; that *Stephananthe* is the most differentiated of the *Perimelitæ*; that *Ptychanthe* and the more specialized forms of *Lissanthe* are the most differentiated of the *Mesomelitæ*; while *Lophanthe* and *Keratanthe* in the one series, *Limnanthe* in the other, constitute lower grades of differentiation, though they are nowise to be regarded as transitional between any of the others.

Thus, on purely morphological grounds and as a mere generalization of the facts, without the introduction of any speculative considerations, the relations of the various types may be represented thus:—


Perimelitæ.
Mesomelitæ.
Most differentiated.
Stephananthe.
Ptychanthe.
Lissanthe.
Keratanthe.
Lophanthe.
Limnanthe.
Actinanthe.
Asteranthe.
Least differentiated.
Haplanthe.
(Hypothetical.)

Or, to put the facts in another way, the several types in each series may be regarded as modifications of a common plan, of which the simplest exemplification is to be found in *Actinanthe* and *Asteranthe* respectively. If so, it is an easy step to the conclusion that both these are slightly diverse modifications of a still more simple, but, at present, purely hypothetical, common form, having the main features of *Actinanthe* and *Asteranthe*, but with the nectarial surfaces either feebly developed on both ovarian and corolline surfaces, or entirely absent. I will call this hypothetical "Ur-gentian," *Haplanthe*.

Thus far I have endeavoured to travel no hair's breadth beyond matters of observation and their obvious relations. It is plain that, even if all the five hundred and odd species of Gentianeæ had been created separately and raised in pots in the Garden of Eden, their morphological relations would have been exactly what they are. But, to a believer in evolution, the significance of these facts is unmistakable. With whatever caution one may be inclined to regard phylogenic speculations, it is hard, in such a case as this, to resist the force of the suggestion, that these morphological relations do really indicate the path which the evolution of the plants composing the Order has followed. At any rate, the evidence is strong enough to justify us in accepting this conception as a good working hypothesis. And there is the more justification for doing so, that, if we regard the morphological facts by the light of Sprengel and Darwin's theory of the origin of flowers, they at once become intelligible.

In foraging for information about the Gentians, immediately after my return to England, I took up Müller's 'Alpenblumen'; and I was exceedingly struck by the views put forward in the remarkable page and a quarter which he devotes to a "Rückblick auf die Gentianarten" (p. 348), and which I here translate:—

"The genus *Gentiana* is fitter than almost any other to furnish a biological explanation, from the arrangements in regard to fertilization, of the systematic grouping based on morphological indications; and to dispose the subdivisions of the system as branches of a parent stem. It is primarily divisible into two main branches, of which the one secretes honey from the lowest part of the ovary, the other from the lowest part of the corolla. If, then, two kinds of nectarial structure have arisen from an original uniform nectarial structure, the common ancestor of these two groups must have secreted honey, both from the base of the ovary and from that of the corolla, as is the case, *e. g.*, in *Saxifraga oppositifolia*; and thus, in the one group the one half, and in the other the other half, must have been specially developed, to the exclusion of its fellow. But it is also conceivable that the ancestors of *Gentiana* were honeyless, and that the two forms of nectary have been developed independently.

"Of the one of the two main branches, we have a lateral twig remaining in *G. lutea*, which stands low down in point of development, and is certainly nearest the common stem. Like *G. lutea*, without doubt, the ancestors of the genus had fully open flowers, with almost free petals, and tempted the appetite of their fertilizers, either with perfectly accessible honey, in the angle between the ovary and the corolla, or only with pollen. In any case, they were open to the visits of very various insects, which therefore subserved cross-fertilization irregularly and, as it were, accidentally (as in *G. lutea*), so that the occurrence of such fertilization was by no means assured, and spontaneous self-fertilization in case of need could not be dispensed with.

"After the development of the nectaries, Bees, and especially Humble-bees, proved the most effective cross-fertilizers; and campanulate flowers adapted to them became developed. In the one branch, unbidden guests were excluded by the formation of deep passages (*Saftlöcher*); and, by the coalescence of the anthers into a ring round the style, cross-fertilization by Humble-bees was assured (*Cœlanthe**). In the other branch, fimbriæ of the petals, at first, afforded an imperfect defence against useless visitors, and narrowing of the flower ensured the contact of the Bees with the stigmas as well as with the anthers (*Crossopetalum**).

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* *Ptychanthe* (mihi).

"Subsequently, in the one main branch, under the conditions already indicated, the *Cœlanthe*-form, adapted to Humble-bees, was bred into the *Cyclostigma*-type†, adapted to Butterflies; whilst in a particular offshoot of the other main branch, the development of the pectines and the narrowing of the corolla around the ovary brought Butterflies as well as Humble-bees into service as cross-fertilizers (*Endotricha* ‡).

"The original yellow colour of the flowers (as in *G. lutea*) was gradually changed into blue by the selective action of Humble-bees; and instructive intermediate stages of this process are seen in the species of *Cœlanthe.* But after the blue coloration was once fixed, the colour maintained itself throughout the process by which Butterflies, by unconscious selection, bred *Cœlanthe* into *Cyclostigma.*"§

I confess that, when I first read this uncompromising application of the theory of flowers, originated by Sprengel and Darwin, to the case of the Alpine Gentians, I thought it somewhat rash, and gave it a very cool and sceptical reception. It occurred to me that if it was a valid explanation of the morphological characters of the flowers at all, it ought to be applicable not only to those of the Alpine *Gentianæ*, but to the whole genus; and, if to the genus, then why not to the whole order? And the chief motive which has led me to spend a good deal of time and trouble in working over a considerable proportion of the species of *Gentiana* and of the genera of Gentianeæ, was the obvious importance of arriving at some conclusion respecting this question.

I do not profess to have settled it; but, so far as I have gone, I have found nothing that conflicts with Müller's extremely ingenious speculation. On the contrary, everything confirms it. As I have already remarked, the principle which underlies the progressive modification of the flower, in each of my series, is the gradual interposition of more and more obstacles in the way of easy access to the nectaries. Yet these obstacles, whether they arise out of a mere narrowing and elongation of the tube of the corolla, as in *Lissanthe,* or out of the development of fimbriæ and pectines (as in *Lophanthe* and *Stephananthe*), or of interlobes, synanthery, and discoidal stigmata (as in *Ptychanthe*), are always of such a nature that they afford no effectual hindrance to the passage of a thin and flexible organ, like the haustrum of a suctorial insect, but only just sufficient obstacle to make the insect an efficient agent in cross-fertilization.

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* *Lophanthe* (mihi).

† *Ptychanthe* (mihi).

‡ *Stylananthe* (mihi).

§ Sir Joseph Hooker ('Flora of New Zealand') observes that the pure blue of the European and Himalayan Gentians is unknown in the Arctic regions and the higher latitudes of the Andes. The widespread *G. montana* has pale whitish-yellow flowers streaked with red or blue. These facts are interesting in relation to the primitive character of the Novo-Zelanian, Australian, and Austro-Columbian Gentians.

Few inquiries would be more interesting and profitable (though undoubtedly few more difficult) than the working out of the geographical distribution of the Gentianeæ in relation to the Insect Faunæ of the several regions in which they occur.

I merely note that those Gentianeæ which have remarkably long infundibulate corollæ are found in regions, such as Madagascar and Guiana, which are tenanted by large Lepidoptera provided with long haustra.

Müller's doctrine respecting the origin of the forms of the flower in the Alpine *Gentianæ* appears to me to be equally applicable to the whole of the Order, and to supply a true cause whereby the morphological facts may be correlated and explained.

I do not suggest that the interaction of cross-fertilizing insects with the variation in the structure of the corolla accounts for all the characters by which the five hundred species of Gentianeæ differ from one another. Why one species is annual and another has a rhizome; why the great majority have opposite palmati-veined leaves, while some have alternate or pennati-veined leaves; why the majority have a single-celled ovary, and yet, in many, the ovary is more or less completely two-celled*; why most are herbaceous, while some are bushy and some are climbers, are problems hardly to be solved by the consideration of the causes which have brought about the modification of the corolla. But I have little doubt that, with larger knowledge, analogous causes will be found to be operative in all these cases. One of the great lessons which Darwin has taught us is faith in the doctrine of sufficient causes; and consequently hesitation in assuming that any structure, however slight or unimportant in appearance, is devoid of significance in relation to either present or past conditions of existence, the chiefest of these being the struggle for existence with competitors, while climate and station probably occupy a very secondary place.

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* The partially, or wholly, two-celled ovary appears to be generally regarded as the result of the gradual introrsion of the margins of the carpellary phyllomes into the cavity of a primitively one-celled ovary. But had "*Haplanthe*" a one-celled ovary? Must not the apocarpous condition precede the syncarpous? Does not the state of the ovary in Apocyneæ and Asclepiadeæ rather suggest that the primitive Gentians (or perhaps, I should rather say, the primitive stock of all these orders) had an ovary like that of a hypogynous Saxifrage?

Even in respect of geographical distribution—upon which climate and station are usually assumed to exercise so great an influence,—facts which have come under my notice in studying the Gentians have led me to be a little sceptical as to the extent of that influence.

At Arolla I never met with a specimen of *Gentiana acaulis* anywhere except in the region between the pine-woods and the snow-line. Yet this same species grows so freely in some parts of Southern England, as to be used for the borders of beds in a kitchen-garden*. The genus *Erythræa*, which is notorious for the slightness of the differences between its "species," is of world-wide distribution. It occurs all over Europe, in the Sinaitic Desert, in Egypt, in Hindostan, in the hottest parts of Australia, and in the moist temperate climate of New Zealand. Mr. Gunn, in a note appended to specimens of *Gentiana montana* in the Kew Herbarium, says that this species occurs everywhere, from the shore to the summit of the mountains. *Gentiana campestris* is said by Hooker and Arnott to be "abundant in Scotland, especially near the sea." It was no less abundant at Arolla from 6400 feet to the snow-line.

In studying, with some care, the geographical distribution of various large and widespread groups of closely allied animals, such as the *Canidæ*, the *Astacomorpha*, and freshwater Fishes, I have been much impressed by the necessity of a most minute study of their morphology as a preliminary to any attempt to deal with the facts of distribution. I think there is no greater mistake than to suppose that distribution, or indeed any other large biological question, can be studied to good purpose by those who lack either the opportunity or the inclination to go through what they are pleased to term the drudgery of exhaustive anatomical, embryological, and physiological preparation.

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* Lady Elizabeth Cust informed me that this was the case at Cobham Park in her childhood.

Elaborate works on Distribution have been published which are of little more value than catalogues of reference, because their authors have been unaware of this necessity. And I may point my remarks by showing that even such a brief and imperfect sketch of the minuter morphological characters of the Gentians as is here presented is fruitful of suggestions in regard to their Distribution.

My studies of Animal Distribution have led me to the belief that the division of the land-surface of the globe into large areas, which corresponds most nearly with the broader facts, may be stated as follows. Europe, Africa, Asia, and North America as far as Mexico form one great province—ARCTOGÆA; in which Ultra-Saharal Africa, Madagascar, Hindostan, and Indo-China are more or less distinctly characterized as subprovinces. For my present purpose it will suffice to speak collectively of the latter as the Southern Arctogæa, in contradistinction to the rest of the province as Northern Arctogæa. South America, with the Isthmus, as far as Mexico, constitutes a second great province, AUSTRO-COLUMBIA; Australia with the adjacent islands a third; while New Zealand and the neighbouring islets may be most conveniently regarded as a fourth.

In mentioning the species of the various types of Gentianeæ which I have examined, I have arranged them under the heads of A, for Northern ARCTOGÆA; B, AUSTRO-COLUMBIA; C, Southern ARCTOGÆA; D, AUSTRALASIA; E, NOVO-ZELANIA.

Adopting this scheme of four great distributional provinces, one of which is subdivided into two regions, the following propositions appear to me to hold good of the Gentianeæ:—

1. Species of the Order are found in all five regions. They flourish within the Arctic Circle and up to the limit of perpetual snow in mountain-ranges. They also abound in sundry tropical climates, both moist and dry. The *Limnanthe* type, represented exclusively by marsh- or water-plants, occurs in all the regions, and will not be further mentioned.

2. The head-quarters of the Order (if we consider the number of types represented) are in the North Arctogæal and the Austro-Columbian regions, both of which contain representatives of all the types.

3. The Australasian, South Arctogæal, and Novo-Zelanian regions are all poorer in types. South Arctogæa contains only three, *Lophanthe*, *Lissanthe*, and *Ptychanthe*; Australasia two, *Lophanthe* and *Lissanthe* (perhaps *Actinanthe*); Novo-Zelania three, *Actinanthe*, *Lophanthe*, and *Lissanthe*.

4. The Australasian and Novo-Zelanian provinces have very few species; in the Northern and Southern Arctogæal regions they are very much more numerous. Their numbers are greatest in Austro-Columbia.

5. Only one species is certainly known to be common to any large extent of two provinces, namely *Gentiana prostrata*, which extends from the Eastern Alps of Europe, by way of Northern Asia and America, to the southern extremity of South America.

6. The only types which certainly occur in all five regions are *Lophanthe*, *Limnanthe*, and *Lissanthe*. *Actinanthe* is known in three; namely the Northern Arctogæal, the Austro-Columbian, and the Novo-Zelanian. I think it probable, however, that it may yet be found in Australia. *Keratanthe* and *Stephananthe* occur in two, Northern Arctogæa and Austro-Columbia; *Ptychanthe* in three, Northern and Southern Arctogæa and Austro-Columbia.

7. Notwithstanding the general similarity of the climatal conditions in the mountain-chains of Northern Arctogæa and Austro-Columbia, and the abundance of Gentians in both, their Gentian Floræ are fundamentally different. In the Pyrenees, the Alps, and the Himalayas, the *Ptychanthe* type is largely represented in relation to the *Actinanthe*, *Lophanthe*, and *Stephananthe* types.

In the Andes it is just the other way. Gentians of the *Actinanthe* and *Lophanthe* types abound, and *Stephananthe* is well represented; while I cannot make sure of more than six representatives of *Ptychanthe*, though this type is so easily recognized that there is little chance of its being overlooked or mistaken. Out of more than 60 species of South-American *Gentianæ*, enumerated in Grisebach's 'Genera' and Weddell's 'Chloris,' it appears that nine, namely, *G. nitida*, *liniflora*, *inflata*, *thyrsoidea*, *crossolæma*, *trichostemma*, *scopulosa*, *filamentosa*, and *Ringii*, belong to *Stephananthe*, and six to *Ptychanthe*; while the rest all belong either to *Actinanthe* or to *Lophanthe*. Judging from the proportion of those which have examined, it seems probable that there are nearly as many of *Lophanthe* as of *Actinanthe*.

And when it is considered that only one species is common to the highlands of Northern Arctogæa and of Austro-Columbia, the contrast between the Gentian Floræ of the two becomes still more striking.

In Sir Joseph Hooker's well-known paper "On the Distribution of Arctic Plants" (Transactions Linn. Society, vol. xxiii.), the following twelve Gentianeæ are stated to occur north of the Arctic Circle:—*Gentiana aurea, propinqua, detonsa, arctophila, Amarella, tenella, glauca, prostrata, nivalis, verna*; *Pleurogyne rotata, Menyanthes trifoliata.*

I have not examined *Gentiana arctophila*; but I believe it to belong, like *G. aurea, propinqua,* and *detonsa,* to the *Actinanthe* type. In this case the components of the Gentian Flora of the Arctic regions may be classified as follows:—

Actinanthe.	Keratanthe.	Lophanthe.	Stephananthe.
5	0	0	2
Limnanthe.	Asteranthe.	Lissanthe.	Ptychanthe.
1	0	0	4

In the Flora of the European Alps I can find no representative of the *Actinanthe* type except *Pleurogyne carinthiaca.* On the other hand, two of its Gentianeæ, *Gentiana ciliata* and *Swertia perennis,* belong to *Lophanthe.*

Passing to the *Stephananthe* type, *Gentiana tenella* is admittedly common to the Alps and the Arctic regions; but the former have *G. germanica, campestris,* and *nana* in place of *G. amarella.* How far any real distinction is to be drawn between *G. amarella* and *G. germanica* is a question for future examination.

Limnanthe is represented by *Menyanthes trifoliata* in both the Arctic and the Alpine regions; *Asteranthe* only in the Alpine; *Lissanthe* in neither.

The ordinarily recognized species of *Ptychanthe* in the proper Alpine region of Europe are some eighteen or nineteen in number. Three of these, namely, *G. verna, nivalis,* and *prostrata,* are also Arctic; but the Gentians of the *acaulis* group, which flourish, along with *verna* and *nivalis,* in the Alps, are unknown in the Arctic regions. Again, the Gentians of the *purpurea* group, though they occur in Southern Scandinavia and Kamtschatka, stop short of the Arctic Circle.

It appears to me that these facts are very difficult to reconcile with the view that the high Alps have been peopled with their Gentianeæ from the Arctic regions or *vice versâ.* The abundance of Gentians of the *Actinanthe* type in the Andes indicates their adaptability to alpine conditions; yet they are absent in the Alps, while well represented in the Arctic regions.

It must be understood that I deal only with the broad facts of the case. Some attempts which I made to study the few forms which abounded at Arolla, with a view of distinguishing the book-species among them, became unsuccessful exactly in proportion to the number of specimens I examined; and I left off with the conviction that I had no means of knowing whether *G. purpurea* was distinct from *G. punctata*, *G. campestris* from *G. germanica*, or *G. verna* from three or four other "species." In *G. campestris* the number of varieties in size, habit, foliation, form, number of parts and colour of the flower, were really astonishing; and I met with the strangest monstrosities. In *G. verna* the range of variation was quite as remarkable. If all the species of *Gentianæ* are in this case, it is perilous to attempt numerical estimates on the foundation of ordinary collections.

DISTRIBUTIONAL DIAGRAM.

NORTH ARCTOGÆA.
Actinanthe.
Keratanthe.
Lophanthe.
Stephananthe.
Asteranthe.
Limnanthe.
Lissanthe.
Ptychanthe.

AUSTRO-COLUMBIA.	SOUTH ARCTOGÆA.	AUSTRALASIA.	NOVO-ZELANIA.
Actinanthe.	....	(?)	Actinanthe.
Keratanthe.	....	....	....
Lophanthe.	Lophanthe.	Lophanthe.	Lophanthe.
Stephananthe.	....	....	....
Asteranthe.	....	....	....
Limnanthe.	Limnanthe.	Limnanthe.	Limnanthe.
Lissanthe.	**Lissanthe.**	Lissanthe.	Lissanthe.
Ptychanthe.	Ptychanthe.	....	....

The names printed in black letters are those of strongly dominant types in the several regions.

If the facts of distribution of the Gentianeæ are adequately stated in the above propositions, one conclusion appears to me to be very clear; and that is, that they are not to be accounted for by migration from any "centre of diffusion," to which a locality can be assigned in the present condition of the world. If the *Gentianæ* of the Andean range had been derived from those of Northern Arctogæa, or *vice versâ*, it seems unaccountable that the proportion of representatives of the types should be so different in the two assemblages; and, still more, that there should be only one species common to both.

There is a well-known case of zoological distribution which presents a certain parallelism with that of the *Gentianæ*. The genus *Tapirus* is represented by certain species in South America, and by another in the Indo-Malayan region. And palæontology furnishes the explanation of the fact by proving the existence of Tapirine animals, which have since died out, over the vast intermediate area in the Middle Tertiary epoch. There has been no migration, but simply local modification of the genus at opposite ends of its primitively continuous area of distribution, with subsequent extirpation over the intermediate space.

I am not aware that any fossil remains of Gentianeæ have been brought to light; but it is known that many of the plants of the Middle Tertiary epoch were extremely similar to those which now exist. Furthermore, it is certain that the great elevated areas of both the Old and the New Worlds existed, and had attained a considerable height, possibly even greater than that which they at present possess, during the Pliocene epoch. Under these circumstances, I see no reason to object to the supposition that species of the genus *Gentiana* itself, closely similar to our existing species, may have, at that time, occupied pretty much the same regions and stations as those in which they are now found, and had already adjusted themselves to their hard conditions of existence. If so, the changes in the physical geography of the world, which preceded and accompanied the Glacial Epoch, must undoubtedly have narrowed the range, and probably extirpated a good many of the pre-Glacial species of *Gentiana*. But the remainder would have as readily found secure refuge in sheltered nooks and valleys, as the existing species do; and, as the climate improved with the passing away of the Glacial epoch, they would start afresh from their fastnesses to compete with other immigrants for the possession of the new localities laid open to them.

Gentiana prostrata may have had its present distribution before the Glacial epoch. In fact, I am more surprised to find only one species widely spread over both the Northern Arctogæal and the Austro-Columbian provinces, than I should be if there were several; and I am not a little disposed to think that a serious critical comparison of the two Floræ, with due attention to the range of variation of the species in each, may bring about a considerable alteration of our views on this subject.

The supposition that the distribution of the Gentianeæ in Pliocene or in Miocene times was substantially similar to what it is now, is of course no solution of the problem of their distribution; it is simply driving the search for that solution further back Is it possible to fix any anterior limit to this retrogression?

I suppose it would be, if one could fix the age of the first appearance of Diptera, Hymenoptera, and Lepidoptera provided with long haustra. For, upon Müller's hypothesis, the existence of the *Keratanthe*, *Stephananthe*, *Lissanthe*, and *Ptychanthe* types presupposes that of such insects. Unfortunately, we are, as yet, hardly in a position to speak positively on this point. The most that can be said is that there is no evidence that they were abundant before the middle of the Mesozoic epoch, or that they existed in Palæozoic times. Free play, therefore, is left to speculation; and I do not think any good grounds could be given for denying the existence of even the more specialized Gentianeæ in the Cretaceous epoch; while the "Ur-Gentian," the hypothetical anemophilous *Haplanthe*, may be dated back almost as much further as probabilities permit us to carry the existence of flowering plants. For it is obvious that a very slight further modification, in the direction of simplicity in *Haplanthe*, would bring about a form of flower which might serve as the starting-point for those of almost all the Orders of Dicotyledons. But speculation as to when or where the hypothetical *Haplanthe* may have originated is, for the present, idle. "Ignoramus" and, I fear, for a long while, "ignorabimus."

Considering how slight the morphological differences between the eight types really are, and that (according to the hypothesis) they have been brought about by the selective operation of agencies of the same order, it seems to me that it would be rash to deny that species belonging to the same type may have arisen in different localities. I do not think it probable that the process of modification and the materials it works upon would be so similar in widely different localities as to give rise to the close similarities which lead us to group individuals in the same species; but the polygeny of genera, and still more of larger groups, appears to me to be highly probable*.

We are very much in the habit of tacitly assuming that because certain plants and certain animals exist only under certain climatal conditions, there is something in what we vaguely call the "constitution" of the plants or animals which binds them to these conditions, and renders it impossible for them to live elsewhere. I wish we could get rid of this word "constitution;" for I take it to be one of the many verbal anodynes by which the discomfort of ignorance is dulled. If it means any thing definite, it merely signifies that there is some morphological or physiological impediment to the existence of the plant or animal, outside the defined conditions; and our business is to find out what that impediment is. When I was at Arolla I was extremely astonished by the distribution of two very common species of *Epilobium* (*E. spicatum* and *E. Fleischeri*), which were flowering at the same time. There was any quantity of the latter among the boulders of the bed of the stream at the bottom of the valley; but nowhere else. And there was any quantity of *E. spicatum* growing on the lateral walls of the valley, from 30 or 40 feet above its bed upwards, but nowhere else. I used to amuse myself by looking for trespassers of either species in the province of the other; but I never could find any. Everybody knows that the seeds of the *Epilobia* are abundant and provided with special aids to distribution by the winds; and there certainly is no failure of breezes in the valley. Every year, therefore, millions of seeds of each species must be scattered over the territory of the other. Why does one thrive, and the other die?

To say this depends on the "constitution" of the two species, is simply to wrap up the fact in another form of words. And I can conceive of no investigation more likely to lead to results of far-reaching importance, than that which should get to the bottom of this, or any analogous case.

Finally, I may put another question. Is anybody in a position to deny that, in the absence of all other phænogamous vegetation, the Gentians might have occupied every region and station on the earth's surface in which flowering plants can exist? Is there any ground for seeking the causes of their distribution elsewhere than in the competition with other plants which they have undergone and are undergoing, and in the course of which it has often happened that the success of a given form in adapting itself to certain conditions has involved a corresponding diminution of the faculty of adapting itself to others?

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* I find weighty remarks on this topic in Engler's "Versuch einer Entwickelungsgeschichte der Pflanzenwelt," 2 Theil, p. 318.

Such are the observations I have to offer. I call them "Notes and Queries;" and I am afraid there are more queries than notes. My hope in offering them to the Society is to stimulate those who are better qualified than I am to carry through a serious botanical inquiry, and who have more time before them than I have to take up the subject. I believe that the systematic and exhaustive study of a single well-chosen Order, and of all the biological problems which it presents, would inaugurate a new era in the progress of Botany. The amount of patient and sagaciously directed labour which is embodied in our standard systematic works is astounding; and the deepest gratitude is due to those who have thus brought the data of Vegetable Morphology and Distribution into a shape in which they can be dealt with. But from the point of view of the Evolution doctrine, it is obvious that Taxonomy and Distribution have to be subjected to a process of revision, which will hardly fail to revolutionize both.

DESCRIPTION OF PLATE II.

A scheme to illustrate the morphology of the flower of the Gentianeæ.

VACCINIUM INTERMEDIUM, *Ruthe*, a new British Plant. By N. E. BROWN, A.L.S., Assistant in the Herbarium, Royal Gardens, Kew.

[Read 5th May, 1887.]

(PLATE III.)

THE discovery of this plant in Britain by Prof. T. G. Bonney, F.R.S., is one of considerable interest to Botanists, not only because it adds one more species to the British Flora in a genus we might scarcely expect to find a further novelty, but chiefly on account of its hybrid origin and its rarity on the continent, where, so far as I can learn, it appears to be local, having been found only in a few parts of Germany, viz.:—in the island of Wollin on the coast of Pomerania; Forest of Jungfernheide, north of Berlin; near Charlottenberg; Auhlan Pomerania, Forest of Stadtforth Hodeheide; Czarinkau in Pomerania; many places of the Nieder Lausitz; Province of Brandenburg, *i. e.* Sommerfeld, Dobrilugk; in Silesia near Nierky, Naumburg on the Bober; on the Kœnighanier Berge near Gorlitz.

(For the above list of localities I am indebted to Mr. A. Bennett, of Croydon, who kindly procured them from Dr. Karl Schumann, the Keeper of the Berlin Herbarium.)

It was first gathered by Prof. Bonney, in August 1886, on Cannock Chase, where it is plentiful in certain spots, *V. Myrtillus* and *V. Vitis-idæa* being also abundant. It is accepted by continental authors as a hybrid between these two species; and from the evidence gathered by Prof. Bonney, and from the fact that its assumed parents grow in the same locality with it, there can be no doubt that this view is correct. And I do not doubt that the plant has originated independently on Cannock Chase, and has not spread to that locality from the continent. The plant appears to produce fruit but rarely, Prof. Bonney, so far as is known to me, only having found two berries, although the plant covers a considerable extent of ground. It will be interesting to determine how far the plant comes true from seed, or if it has a tendency to revert in any way to its parent forms.

It is possible that this novelty may exist undetected in other localities, as its general resemblance to *V. Myrtillus* may have caused it to have been overlooked. The best means of detecting the plant superficially appears to be by its evergreen habit; but upon this and other points I will quote its discoverer's own words. Prof. Bonney writes, Sept. 1886, speaking first of the geological formation and general nature of the vegetation of the locality:—"The rock is the Pebble-bed of the Bunter group, and there is hardly any surface soil. Except where Firs have been planted, there are not many trees, only now and then scattered Birches, Oaks, or (more rarely) Thorns; occasionally, towards the margin of the Chase, Furze is abundant; but the ground is generally covered with *Calluna vulgaris*, *Erica cinerea* (and more rarely *E. tetralix*), *Vaccinium Myrtillus*, and *Pteris aquilina*. *Vaccinium Vitis-idæa* is not so generally found, but is very abundant in certain localities. The new *Vaccinium* is readily distinguishable from *V. Myrtillus*, which at first sight it more resembles, by the deeper and richer green of the leaf (*V. Myrtillus* at this time of the year [September] has rather a yellow-green tint), and by a more free mode of growth, the sprays curving very slightly outwards and downwards, while *V. Myrtillus* is apt to be a little stiff in its growth. The different tint and foliage caught my eye, and then I noticed the flower." In other letters to Mr. W. T. Thiselton Dyer, F.R.S., Prof. Bonney writes:—"I saw the plant growing in considerable abundance; all about it grew the other two *Vaccinia*, Heath, &c. I was struck by the different tint of green of the leaf, the more free mode of growth, larger size, and the lighter tint of the flower. Another singular point is that it was all in flower. We searched for some time and could not find a fruit, yet *V. Myrtillus* and *V. Vitis-idæa* are in full fruit, and flowers are rare." "The flower (of *V. intermedium*) has a very marked scent, something like hawthorn; it is certainly now (Aug. 29th) in full bloom." "I walked this morning (Dec. 23, 1886) to the spot where the hybrid *Vaccinium* is growing. I find that it is practically evergreen; *V. Myrtillus* is quite bare of leaves, except here and there some low-growing, apparently young shoots; all the strong healthy plants are bare. But the hybrid has its leaves still green and fresh-looking. In one or two cases a few leaves seemed to have dropped, but one may fairly say that it is as exceptionally deciduous as the other is evergreen. *V. Vitis-idæa* is of course in full leaf, and even had in some cases its seeds. I could find no seed on the hybrid. This evergreen habit is remarkable, and bears out what you said as to the greater affinity with *V. Vitis-idæa*. Yet, curiously enough, a passer-by would be more likely to confuse the plant with *V. Myrtillus* than with

V. Vitis-idæa. I am never in danger of mistaking it for the latter, but generally have to beware lest I mistake it for the former. The round stem seems to be one of the most marked differences from *V. Myrtillus.* Of that plant the peculiar ridged stem shows very clearly now that there are no leaves."

The above quotations give, better than anything I could write, the superficial characteristics of the living plant; to which may be added, as further marks of distinction whereby to separate it from *V. Myrtillus,* that the leaves are thicker and firmer in texture, less rounded at the base, and with a deeply impressed venation; the flowers are rather different in form and have a tendency to a racemose arrangement, and the filaments are hairy. From *V. Vitis-idæa* the larger size and different habit, the absence of punctate dots on the under surface of the leaf (there are, however, minute glandular hairs), the more urceolate shape of the corolla, and the presence of awns at the back of the anthers, at once distinguish it.

The following are the specific characters of *V. intermedium*:—

VACCINIUM INTERMEDIUM, *Ruthe, Flora der Mark Brandenburg und der Niederlausitz,* p. 377, t. 1; *Guimpel und Klotzsch, Pflanzenabbildungen und Beschreibungen zur Erkenntniss offizineller Gewächse,* t. 7; *Koch, Synopsis Floræ Germanicæ et Helveticæ,* ed. 2, p. 545; *Reichenbach, Icones Floræ Germanicæ et Helveticæ,* vol. xvii. p. 81, t. 1169. f. iv, v, 8–10.

Plant 20–30 cm. high, forming a dwarf, bushy, evergreen shrub. Stem terete, faintly angular above, green, minutely puberulous on the younger parts. Leaves alternate, spreading, evergreen; petiole 1–2 mm. long, puberulous; lamina elliptic or obovate, averaging from 15–25 mm. long, and 8–12 mm. broad, obtuse with a very small glandular apiculus, more or less cuneate at the base, denticulate on the recurved margins, firm in texture, bright green and glabrous above, with impressed reticulate venation, paler beneath and very sparsely covered with minute stipitate glands. Flowers sometimes solitary in the axils of the leaves, but more generally in short terminal bracteate racemes, drooping. Bracts more or less leafy. Pedicels 2–4 mm. long, glabrous, bibracteolate; bracteoles linear-lanceolate, about 2 mm. long. Calyx-lobes short, broadly ovate, acute, glabrous, green. Corolla 4–5 mm. long, urceolate-campanulate, with five short, deltoid, slightly spreading lobes, pale pink, scented. Filaments hairy, whitish. Anthers with two apical tubes as long as the pollen-cells, and two dorsal awns at the base of the tubes, orange-yellow, minutely puberulous except the tubes. Ovary hemispherical; style filiform; stigma simple. Fruit globose, of the size of a small pea, dark violet.

Postscript.—Since the above was read, Mr. Robert Garner, F.L.S., in a letter, has pointed out to me that he discovered this plant some years ago in Maer Woods, Staffordshire, and exhibited it at a meeting of the Linnean Society in 1872 (Proc. Linn. Soc. 1871–72, p. 31); and also published an account of it in 'Science Gossip' for 1872, p. 248, figs. 174–175, under the title of "A Curious British Plant." As no name was given to it by Mr. Garner, and as it does not appear to have been placed in competent hands for identification, I had no clue to Mr. Garner's previous discovery of the plant. I have seen the specimens exhibited by Mr. Garner to the Linnean Society, and they are undoubtedly the same as Prof. Bonney's plant; they are respectively dated Dec. 1870 (flowering specimens!) and Oct. 1871 (fruiting specimens). This gives a second British locality for the plant. Mr. Garner writes as follows concerning it:—"The spot where I found it, Maer Woods, in this county, had often been trod by Mr. Darwin, to whom I sent the plant as a hybrid, and he suggested that the seeds would show infertility; and on inspection, whilst in the Cowberry (*V. Vitis-idæa*) I found a dozen or more good seeds, and twice as many in the Bilberry (*V. Myrtillus*), there were not more than two to five in the berries of the plant in question." In the berries upon Prof. Bonney's specimen there appear to be two good seeds.—N. E. Brown.

DESCRIPTION OF PLATE III.

Fig. 1. The Plant. Fig. 2. Leaf. Fig. 3. Raceme of flowers. Fig. 4. Stamen, front and back views. Fig. 5. Ovary and style. Fig. 6. Transverse section of ovary. Fig. 7. Fruit.

Figs. 1, 2, & 7, natural size; the rest magnified.

Hermann's Ceylon Herbarium and Linnæus's 'Flora Zeylanica.'

By Henry Trimen, M.B., F.L.S., Director, Royal Botanic Gardens, Peradeniya, Ceylon.

[Read 2nd December, 1886.]

The collection of dried plants and the drawings of living ones made in Ceylon by Paul Hermann in the latter half of the 17th Century possess a special interest as being the first important contribution of material towards a knowledge of the botany of the East Indies; but the premature death, in 1695, of the excellent botanist who made it, prevented its becoming available to the scientific world of his time. Indeed, beyond the publication in his 'Hortus Acad. Lugd.-Bat. Catalogus,' in 1687, of some brief descriptions and reduced copies of a few of the drawings, Hermann himself printed nothing on Ceylon botany. After his death, however, some of his MSS. were edited by the illustrious botanist W. Sherard (for the benefit of the widow), and in the 'Paradisus Batavus' of 1698 there are included some more of the descriptions and reduced figures of Ceylon plants. In 1717 also there appeared as an anonymous tract of 71 pages a catalogue of the Herbarium of Ceylon plants under their Singhalese names, no doubt printed from Hermann's own MSS. This bears the title of 'Musæum Zeylanicum,' and the editor is well known to have been also W. Sherard*. In the brief preface it is stated that the plants enumerated were collected either wild or growing in the gardens of the natives, and pasted into three volumes without any order, and probably just as they came to hand. The editor adds that a fourth volume would be made up, and gives at the end of the Catalogue, as "aliæ plantæ chartis non agglutinatæ," a large number of additional names.

The herbarium of which this was the catalogue appears to have been completely lost sight of till the year 1744, when August Günther, Apothecary-Royal at Copenhagen†, sent to Linnæus at Upsala to be named a collection of Indian plants in five volumes, one being a volume of drawings. The great botanist was not long in discovering what a treasure he had in his hands—no other than Hermann's own herbarium of Ceylon plants just as enumerated in the 'Musæum,' with the addition of the promised fourth volume and a fifth volume of drawings*. He at once set to work at its examination; and after two years' labour produced in 1747 the 'Flora Zeylanica,' which he dedicated to Günther. In this book Linnæus has classified all the plants in the herbarium which he could determine (429 in number) under their genera†; and these are duly arranged in accordance with his sexual system. Under each species he refers to the names in the 'Musæum,' and at the end he gives lists of those names (228 in number) which he was unable (in nearly all cases from the absence of specimens) to refer to any genus. The whole number of plants enumerated is thus 657. In the herbarium itself he has added to Hermann's labels a reference to the number of the species in his own 'Flora Zeylanica.'

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* A second edition, with a new title only, was published in 1726.

† There are five letters from Günther to Linnæus in the correspondence of the great naturalist preserved in the Library of the Linnean Society. The dates of these are from 1744 to 1749. Two are written in Swedish and three in Latin.

At this period of Linnæus's career he had not yet initiated his binomial system of nomenclature; thus no species in the 'Flora Zeylanica' are *named* in the modern sense, but are only referred to their Linnæan genera. When, however, in 1753 that really epoch-making book the 'Species Plantarum' was published, in which specific names were systematically employed, Linnæus was careful to quote under them the numbers of the 'Fl. Zeylan.,' and thus the specimens of Hermann's herbarium become types for many of Linnæus's species. It is this of course which gives to this interesting collection its great scientific value, and renders it an important supplement to the herbarium of Linnæus himself in the possession of this Society; especially as the large majority of the species in Hermann's herbarium are unrepresented in Linnæus's own collection. It is this consideration mainly which has led me to spend some time in a re-investigation of its contents; and the results of this examination I now offer to the Society which bears Linnæus's name.

As is well known, Hermann's herbarium is now in the Botanical Department of the British Museum. Its history since it left Linnæus's hands is briefly as follows:—From Günther it passed into the possession of Count A. G. Moltke‡, at whose death it was purchased by Prof. Treschow of Copenhagen. The latter sold it to Sir J. Banks for £75 §; and it passed, with the rest of the Banksian collections, into the keeping of the Trustees of the British Museum in 1827. Since it came into the hands of Sir Joseph Banks, it has been frequently the object of examination. Especially it was very thoroughly gone over by Dryander, who, in a copy of the 'Flora Zeylanica' in the Banksian Library (now in the Botanical Department), entered against each species references to the volumes and folios of the herbarium where the corresponding specimens are to be found. These useful notes have much facilitated my examination. Robert Brown, Dryander's successor in the charge of the Banksian collections, was also in the habit of consulting the herbarium, and frequently quotes its specimens. Dr. Wight was unfortunately able to consult it only to a limited extent*. Nor should I forget to mention that my friend Mr. W. Ferguson, F.L.S., of Colombo, when on a visit to England thirty years ago, carefully examined the whole collection, and, I believe, possesses copious notes upon the plants it contains.

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* See the Preface to Fl. Zeylan. p. 17.

† In Linnæus's own copy of the 'Mus. Zeylan.' in the Society's Library, he has entered in the margin against each name the genus to which he referred it.

‡ Rottböll, Descript. p. 49.

§ MS. Note by Dryander in the Herbarium.

Hermann's stay in Ceylon extended over several years, at least from 1672–1677, and perhaps a year or two on either side of that period. He was called to the Chair of Botany at Leyden in 1679, being then only thirty-three years of age. Notwithstanding his youth, he held, while in Ceylon, the office of Chief Medical Officer in the service of the (Dutch) East India Company. At this period the Dutch held most of the coast towns, having wrested Colombo from the Portuguese only so recently as 1655; but the whole interior still remained under the rule of the native Emperor of Kandy, at this time the powerful Raja Singha; and it is interesting to note that our countryman Robert Knox was undergoing his long captivity in the interior at the very period of Hermann's sojourn at Colombo. It may be inferred from the herbarium, which is a representative one of the environs of Colombo, that Hermann neither travelled far from the coast, nor had the opportunity of penetrating into any tract of untouched forest.

Besides the herbarium under consideration, Hermann formed another whilst in Ceylon, which he sent to J. Commelin at Amsterdam. It was from this collection (combined with that made by J. Hartog, which was sent from Ceylon to Voss, Curator of the Amsterdam Gardens) that J. Burman, Commelin's successor, compiled his 'Thesaurus Zeylanicus'*. This book was published in 1737 with 110 well-drawn plates containing numerous figures, and is systematically quoted by Linnæus throughout the 'Flora Zeylanica'†. Hermann also sent specimens to other botanists of the time, especially to Gronovius, from whose herbarium there are several of Hermann's plants in the Banksian collection.

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* Preface to 'Prod. Fl. Ind. Or.' p. x.

The specimens, considering their age and the vicissitudes the Collection has sustained, are in very fair condition; and in the few cases where identification is uncertain, this arises more from the material being originally scanty or imperfect than from any deterioration since its collection.

A considerable proportion of the plants (about fifty) are exotics, and gathered doubtless from gardens. It is of interest to see at what an early date many of these were already common in Ceylon. Most are of course Old-World plants; but a dozen or more are of American origin, as the Custard-Apple, Guava, Cashew-nut, Capsicum, and Cotton.

But besides these cultivated exotics, the list will be found to contain two or three species from the Cape. These are erroneous inclusions; but the explanation of them is very simple. Hermann called at the Cape, as was usual, on his voyage out, and spent a few days there collecting. The plants gathered there were kept out of the first three volumes of the herbarium, which were no doubt prepared by Hermann himself; but the maker of the fourth volume pasted in Ceylon and Cape plants indiscriminately; and they are mixed up even on the same folios. Linnæus was fully aware of this (see preface to 'Fl. Zeylan.' p. 18), and has omitted all notice of the Cape specimens with the exception of two (see nos. 41 and 307), which he evidently supposed to be from Ceylon. It is only surprising that he avoided the inclusion of more.

It will be found that a few changes of name will be necessitated by this re-examination of the Linnean types in this Collection. It must be confessed that Linnæus has rendered some of his species obscure by erroneous synonymy; in working out the 'Flora Zeylanica' he evidently endeavoured to embody as much as possible of what had been previously published of the plants of the "East Indies" generally; and he has not unfrequently given under the Ceylon species synonyms and references which belong to quite different Indian or Javan plants. In most, though not all, of these cases I think it must be allowed that the Hermannian *specimens* should determine what was the plant intended by Linnæus rather than his book references.

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* See Preface to that book.

† Linnæus had assisted Burman in the preparation of this book when his guest at Amsterdam in 1735.

In the following list of determinations the first column gives the consecutive numbers of the species in the 'Flora Zeylanica,' and each number is immediately followed by the name given to it by Linnæus in his 'Species Plantarum' (1st edition), or in his subsequent systematic works. The second column contains my determinations of the type specimen or specimens representing the species in Hermann's herbarium*. When the word (*drawing*) is appended, it signifies that there is a drawing only to represent the species and no dried specimen. The words *no specimen* mean that there is neither dried specimen nor drawing.

1. Canna indica, Sp. 1	C. indica, *L.*
2. Amomum Zerumbet, Sp. 1	Zingiber Zerumbet, *Rosc.* (*drawing*).
3. Amomum Zingiber, Sp. 1	Zingiber officinale, *Rosc.*
4. Amomum Cardamom, Sp. 1	*No specimen.*
5. Costus arabicus, Sp. 2	Alpinia Galanga, *Sw.* (*drawing*).

The plant figured is evidently the "Kaluwala" of the Singhalese, much cultivated for its aromatic rhizomes. These are known in the drug market of London as Galangal or Greater Galangal roots.

6. Curcuma rotunda, Sp. 2	*No specimen.*
7. Curcuma longa, Sp. 2	C. longa, *L.*
8. Kaempferia Galanga, Sp. 2	K. Galanga, *L.* (*drawing*).
9. Kaempferia rotunda, Sp. 2	K. rotunda, *L.* (*drawing*).
10. Boerhaavia diffusa, Sp. 3	B. diffusa (*drawing*).
11. Nyctanthes arbor-tristis, Sp. 6.	*No specimen.*
12. Nyctanthes Sambac, Sp. 6	Jasminum Sambac, *Ait.*
13. Jasminum azoricum, Sp. 7	*No specimen.*
14. Chionanthus zeylanica, Sp. 6.	Linociera purpurea, *Vahl.*
15. Eranthemum capense, Sp. 9	Dædalacanthus montanus, *J. And.*

In spite of Linnæus's specific name, this is not a South-African plant. He confuses it with another plant of Hermann's, and gives the habitat as "in Æthiopia."

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* The names employed are usually those of the 'Flora of Brit. India' or of my 'Systematic Catalogue of the Plants of Ceylon' (1885).

16. Justicia Adhatoda, Sp. 15	Adhatoda Vasica, *Nees*.
17. Justicia Ecbolium, Sp. 15	Ecbolium Linneanum, *Kurz*.
18. Justicia Betonica, Sp. 16	J. Betonica, *L*.
19. Justicia procumbens, Sp. 16 ..	J. procumbens, *L*.
20. Justicia repens, Sp. 16	Rungia repens, *Nees*.
21. Justicia echioides, Sp. 17	Andrographis echioides, *Nees*.
22. Utricularia vulgaris, Sp. 18 ..	Utricularia flexuosa, *Vahl*.
23. Utricularia cærulea, Sp. 18 ..	U. cærulea, *L*.
24. Ballota disticha, Mant. 83....	Anisomeles ovata, *Br*.
25. Anthoxanthum indicum, Sp. 28.	Perotis latifolia, *Ait*.
26. Piper nigrum, Sp. 28.........	Piper nigrum, *L*., and P. Betle, *L*. ?

The specimens are mostly *P. nigrum*; but one seems rather to be referred to the next.

27. Piper Betle, Sp. 28..........	P. Betle, *L*.?

The specimens have smaller and narrower leaves than the ordinary cultivated Betel Pepper of Ceylon. Burman's t. 83. fig. 2 well represents them, and is quoted with approval by Linnæus.

28. Piper Malamiris, Sp. 29	P. Betle, *L*., var.?

This name is doubtfully applied by authors. The specimens consist of leaves only, and appear to belong to a variety of the Betel-plant, but are only 5-nerved. The name "Wal miris," given by Hermann, however, means *wild* pepper, and not Betel. Linnæus has taken another Singhalese name, "Malamiris" (also given by Hermann in Mus. Zeyl. p. 24), as his specific name. I cannot understand the note *P. Amalago* in Fl. Brit. Ind. v. p. 95, as there is no reference to Fl. Zeyl. no. 28 under that species in Linn. Sp. i. p. 9.

In the Banksian Herbarium there is another specimen from Hermann, sent to Gronovius, and labelled "Malamiris, Bakamumumiris, & Walmiris" by the former. This has 7-nerved leaves, and appears different from the specimens in Hermann's own herbarium.

29. Piper Siriboa, Sp. 29	P. Siriboa, *L*.

The specimen is the "Rata-bulat-wel" (=foreign Betel) of the Singhalese, which is much cultivated, and is supposed to have been introduced from the Malay Islands. I agree with C. de Candolle and Sir J. Hooker (Fl. B. Ind. v. p. 85) in considering it a large-leaved form of *P. Betle*.

30. Piper longum, Sp. 29	P. longum, *L*.
31. Commelina nudiflora, Sp. 41 ..	Aneilema nudiflora, *R. Br*.
32. Commelina cristata, Sp. 42 ..	C. cristata, *L*. (*drawing*).
33. Tamarindus indica, Sp. 34	T. indica, *L*.

34. Olax zeylanica, Sp. 34	O. zeylanica, *L.*
35. Xyris indica, Sp. 42	*No specimen.*
36. Cyperus rotundus, Sp. 45	C. rotundus, *L.*
37. Cyperus Haspan, Sp. 45	C. Haspan, *L.*

There is a double error in the name *Haspan*. The word is properly given as "Halpan" by Hermann (Mus. Zeyl. p. 23); but was misprinted in Burman's Thes. Zeyl. p. 108, whence Linnæus quoted it. But the Singhalese "Halpan" is not this species of *Cyperus*, but *Fimbristylis globulosa*, Wall.

38. Scirpus echinatus, Sp. 50	Cyperus umbellatus, *Benth.*, var.
39. Scirpus capillaris, Sp. 49	Fimbristylis barbata, *Benth.*
40. Scirpus dichotomus, Sp. 50	Fimbristylis diphylla, *Vahl.*

The specimen is merely a young and dwarf state of *Fimbristylis diphylla*, and neither the *F. dichotoma*, Nees, nor the *F. dichotoma*, Vahl.

41. Bobartia indica, sp. 54	Bobartia spathacea, *Ker.*

This is one of the Cape plants that have unfortunately been enumerated among those of Ceylon. The specimens are in the fourth volume of the herbarium, which, as already mentioned, was known to Linnæus to be a mixture of plants from both countries; and it is not clear why he included it in the 'Flora Zeylanica.' Botanists have been further misled by Lamarck, who, professing to figure *Bobartia indica*, has given a drawing of some Cyperaceous plant (Ill. i. t. 40), which Bentham (Gen. Plant. iii. pp. 698, 1015) and Clarke (Journ. Linn. Soc., Bot. xxi. p. 111) refer to a *Cyperus* of the *C. arenarius* group and to *C. pachyrhizus*, Nees, respectively. But Hermann's specimens are the Cape *Moræa spathacea*, Willd., as was demonstrated and figured by Schumacher in Act. Soc. Nat. Scient. Hafn. iii. p. 8, t. 1. Of course the genus *Bobartia* of Linn. will stand; but his specific name *indica* must be superseded, and the plant take the name of *Bobartia spathacea*, Ker, as Baker correctly has it (Journ. Linn. Soc., Bot. xvi. p. 114).

42. Panicum compositum, Sp. 57	Oplismenus compositus, *Roem. & Sch.*
43. Panicum arborescens, Sp. 59	P. ovalifolium, *Poir.*

The specific name of Linnæus is absurd; for *P. ovalifolium* is a humble grass; and his remark "altitudine certat cum altissimis arboribus" could only apply to a Bamboo. On the confusion as to this name in Linnæus's own herbarium, see Munro in Journ. Linn. Soc., Bot. vi. p. 38.

43. Obs. *Not named*	Isachne australis, *R. Br.*

This is the *I. meneritana*, Poir. Encycl. Méth. Suppl. iii. p. 185, an unnecessary synonym. (See Journ. Bot. 1885, p. 271.)

44. Panicum glaucum, Sp. 60	Pennisetum typhoideum, *Pers.*
45. Andropogon Nardus, Sp. 1046.	A. Nardus, *L.*

Hermann's specimen is the Citronella Grass, grown for its essential oil in the south of Ceylon. The native name he gives, "Pengriman," is also clearly intended for "Pangiri-mana" (=acid or sour mana), by which it is generally known. (See also Bentley and Trimen, 'Medicinal Plants,' tab. 297.)

46. Poa amabilis, Sp. 68	Eragrostis plumosa, *Link.*

Linnæus's *Poa amabilis* has given rise to some synonymy. The specimens here are *Eragrostis plumosa*, with which the specimens in Linnæus's own herbarium also agree. (See Munro, Journ. Linn. Soc., Bot. vi. p. 43.)

47. Arundo Bambos, Sp. 81	*No specimen.*
48. Eriocaulon quinquangulare, Sp. 87	E. quinquangulare, *L.*
49. Eriocaulon sexangulare, Sp. 87.	E. sexangulare, *L.*

The name *E. sexangulare*, L., has been quite misapplied in Ceylon, where it has been used (*e. g.* in Thw. Enum. Plant. p. 341) for the small plant (C. P. 795) called *E. Thwaitesii* by Koernicke. Hermann's type-specimens show it to be the plant (C. P. 220) referred by Thwaites to *E. Wallichianum*, Mart.

50. Eriocaulon setaceum, Sp. 87 ..	E. setaceum, *L.*
51. Mollugo pentaphylla, Sp. 89 ..	M. pentaphylla, *L.* (M. stricta, *L.*).

A variety only of *M. stricta*, but the name *pentaphylla* has priority.

52. Mollugo oppositifolia, Sp. 89 ..	M. oppositifolia, *L.* (M. Spergula, *L.*).

In this case also *M. oppositifolia*, L., should take the place of the generally used, but later, *M. Spergula*, L.

53. Cephalanthus orientalis, Sp. 95.	Sarcocephalus cordatus, *Miq.* (*drawing*).
54. Ixora coccinea, Sp. 110	I. coccinea, *L.*
55. Ixora alba, Sp. 110	I. coccinea, *L.*, var.
56. Pavetta indica, Sp. 110	P. indica, *L.*
57. Avicennia officinalis, Sp. 110 ..	*No specimen.*
58. Elæagnus latifolia, Sp. 121	E. latifolia, *L.*
59. Tomex tomentosa, Sp. 118. (Callicarpa lanata, Mant. ii. 331.)	Callicarpa lanata, *L.*

60.	Cissus vitiginea, Sp. 117	Vitis Linnæi, *Wall.*
61.	Exacum sessile, Sp. 112	E. sessile, *L.*
62.	Spermacoce hispida, Sp. 102	S. hispida, *L.*
63.	Hedyotis fruticosa, Sp. 101	H. fruticosa, *L.*
64.	Hedyotis auricularia, Sp. 101	H. auricularia, *L.*
65.	Hedyotis herbacea, Sp. 102	Oldenlandia Heynei, *R. Br.*
66.	Ludwigia perennis, Sp. 119	L. parviflora, *Roxb.*
67.	Oldenlandia umbellata, Sp. 119	O. umbellata, *L.*, and O. corymbosa, *L.*
68.	Oldenlandia biflora, Sp. 119	O. biflora, *L.* (O. paniculata, *L.*).

O. biflora is not separable as a species from *O. paniculata*, L., but is merely a few-flowered variety. Unless it be thought that the name is too little appropriate, *O. biflora*, as the older, should be the name retained.

69.	Coldenia procumbens, Sp. 125	C. procumbens, *L.*
70.	Heliotropium indicum, Sp. 130.	H. indicum, *L.*
71.	Borrago indica, Sp. 137	*No specimen.*
72.	Menyanthes indica, Sp. 145	Limnanthemum indicum, *Thw.*
73.	Plumbago zeylanica, Sp. 151	P. zeylanica, *L.*
74.	Convolvulus Turpethum, Sp. 155.	Ipomœa Turpethum, *R. Br.*
75.	Convolvulus Pes-capræ, Sp. 159	Ipomœa biloba, *Forsk.* (*drawing*).
76.	Evolvulus alsinoides, Sp. ed. ii. 392	E. alsinoides, *L.*
77.	Ipomœa Quamoclit, Sp. 159	*No specimen.*
78.	Ipomœa Pes-tigridis, Sp. 162	I. Pes-tigridis, *L.*
79.	Ipomœa hepaticæfolia, Sp. 161.	I. hepaticæfolia, *L.* (*drawing*).

A variety of *I. Pes-tigridis*, L., only.

80.	Rondeletia asiatica, Sp. 172	*No specimen.*
81.	Morinda umbellata, Sp. 176	M. umbellata, *L.*
82.	Morinda citrifolia, Sp. 176	M. citrifolia, *L.*, and M. tinctoria, *Roxb.*
83.	Lonicera parasitica, Sp. 175. (Loranthus loniceroides, Sp. ed. ii. 473.)	Loranthus loniceroides, *L.*
84.	Mussænda frondosa, Sp. 177	Mussænda frondosa, *L.*
85.	Mirabilis Jalapa, Sp. 177	*No specimen.*
86.	Datura Metel, Sp. 179	*No specimen.*
87.	Rhamnus Napeca, Sp. 194	Zizyphus Napeca, *Willd.*

Kept up as a species by Lawson (Fl. B. Ind. i. p. 635). It is closely allied to *Z. lucida*, Moon; but differs by its broader and abruptly acuminate leaves, with much less secondary venation, and by the very rufous woolly stems and inflorescence. I have never met with this in Ceylon.

88.	Rhamnus Œnoplia, Sp. 194	Zizyphus Œnoplia, *Mill.*
89.	Rhamnus Jujuba, Sp. 194	Zizyphus Jujuba, *Lam.*
90.	Chironia trinervia, Sp. 189	Exacum zeylanicum, *Roxb.*
91.	Strychnos Nux-vomica, Sp. 189	S. Nux-vomica, *L.*
92.	Capsicum annuum, Sp. 188	C. annuum, *L.*, var.
93.	Solanum Melongena, Sp. 186	S Melongena, *L.*

94.	Solanum indicum, Sp. 187 ..	S. indicum, *L.*
95.	Solanum sodomæum, Sp. 187	S. xanthocarpum, *Schrad. & Wendl.*, var. Jacquini, *Thw.*
96.	*Not named*	*No specimen.*
97.	Physalis angulata, Sp. 183 ..	P. angulata, *L.*
98.	Ceanothus asiaticus, Sp. 196	Colubrina asiatica, *Brong.*
99.	Vitis indica, Sp. 202	V. indica, *L.* (V. erioclada, *W. & A.*).
100.	Achyranthes corymbosa, Sp. 205	Polycarpæa corymbosa, *Lam.*
101.	Celosia nodiflora, Sp. 205	Allmania nodiflora, *R. Br.*
102.	Celosia lanata, Sp. 205	Ærua javanica, *Juss.*
103.	Achyranthes lappacea, Sp. 204	Pupalia atropurpurea, *Moq.*
104.	Illecebrum lanatum, Mant. ii. 344	Ærua lanata, *Juss.*
105.	Achyranthes aspera, Sp. 204..	A. aspera, *L.*
106.	Cerbera Manghas, Sp. 208 ..	Tabernæmontana dichotoma, *Roxb.* (*The drawing* Cerbera Odollam, *Gærtn.*)

The specimen is certainly *Tabernæmontana dichotoma*; but the drawing and most of Linnæus's synonyms and the native name given are for *Cerbera Odollam*. These two plants had been previously also confounded by Burman, who in his Thes. Zeyl. figures (t. 70. f. 1) the leaves and flowers of *Tabernæmontana* along with the fruit of *Cerbera*; and perhaps Hermann himself did not discriminate the two plants.

107.	Nerium antidysentericum, Sp. 209	Wrightia zeylanica, *R. Br.*
108.	Nerium Oleander, Sp. 209 ..	N. Oleander, *L.*
109.	Nerium divaricatum, Sp. 209	Tabernæmontana coronaria, *R. Br.*
110.	Ceropegia biflora, Sp. 211	C. biflora, *L.* (*uniflorous state*). (C. intermedia, *Wight*) (*drawing*).

The flowers are by no means always in pairs; but the name *biflora* may be allowed to stand, and must supersede Wight's far later name.

111.	Asclepias lactifera, Sp. 216 ..	Gymnema lactiferum, *R. Br.*
112.	Asclepias gigantea, Sp. 214 ..	Calotropis gigantea, *R. Br.*
113.	Periploca indica, Sp. 211	Hemidesmus indicus, *R. Br.*
114.	Apocynum frutescens, Sp. 213	Ichnocarpus frutescens, *R. Br.*
115.	Gomphrena globosa, Sp. 224	Gomphrena globosa, *L.*
116.	Gomphrena sessilis, Sp. 225..	Alternanthera triandra, *Lam.*
117.	Nama zeylanica, Sp. 226	Hydrolea zeylanica, *Vahl.*
118.	Hydrocotyle asiatica, Sp. 234.	*No specimen.*
119.	Basella rubra, Sp. 272	Basella rubra, *L.* (*drawing*).
120.	Drosera rotundifolia, Sp. 281.	D. Burmanni, *Vahl.*
121.	Drosera indica, Sp. 282......	D. indica, *L.*
122.	Gloriosa superba, Sp. 305	G. superba, *L.*
123.	Asparagus falcatus, Sp. 314 ..	A. falcatus, *L.*
124.	Asparagus sarmentosus, Sp. 314	A. sarmentosus, *L.* (*drawing*). (A. gonocladus, *Baker*?)

As there is no specimen of *A. sarmentosus* in the collection, we have only the drawings by which to determine what Linnæus meant by the name. The drawings were published on a reduced scale in Hermann's Hort. Lugd.-Bat. Cat. tt. 63 & 650, and show a plant with flat cladodes. By many subsequent botanists the name has been erroneously applied to a Ceylon variety of *A. racemosus*, Willd.; and specimens so named are common in herbaria. The *sarmentosus* of Thwaites, Enum. Plant. p. 337, is *A. racemosus.* More recently the name has been transferred to a Cape species, and is so applied by Baker in his revision of the genus (Journ. Linn. Soc., Bot. xiv. p. 625). I see no reason to believe that Hermann's figure was not made from a Ceylon plant*; and I am inclined to think it represents *A. gonoclados*, Baker, a frequent species in several parts of Ceylon. But as the confusion can scarcely be cleared up in the absence of a specimen, the name *A. sarmentosus*, L., had perhaps better be abandoned.

125. Polianthes tuberosa, Sp. 316	P. tuberosa, *L.*
126. Pancratium zeylanicum, Sp. 290	P. zeylanicum, *L.* (*drawing*).
127. Crinum asiaticum, Sp. 292	C. asiaticum, *L.* (*drawing*).
128. Burmannia disticha, Sp. 287	B. disticha, *L.*
129. Pontederia hastata, Sp. 288	Monochoria hastæfolia, *Presl.*
130. Aloe hyacinthoides, Sp. 321	*No specimen.*
131. *Not named*	Pandanus odoratissimus, *L. f.* (*drawing*).
132. Acorus Calamus, β. verus, Sp. 324	*No specimen.*
133. Flagellaria indica, Sp. 333	F. indica, *L.*
134. Lawsonia spinosa, Sp. 349	L. alba, *Lam.*
135. Lawsonia inermis, Sp. 349	L. alba, *Lam.*
136. Memecylon capitellatum, Sp. 349	M. capitellatum, *L.*, and another species of Memecylon.

I look upon *M. capitellatum* as a well-marked species always to be easily recognized; it is the "Weli-kaha" of the Singhalese and is well figured in Burman's Thes. Zeyl. t. 30. Clarke has, however, reduced it to a variety of *M. edule* in Fl. Brit. Ind. ii. p. 564; but his *M. edule* is a very large concatenation of plants, including also the quite distinct *M. umbellatum*, Burm., "Kora-kaha" of the Singhalese.

One of Hermann's specimens is a different and undeterminable species of *Memecylon.*

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* The whole of the Drawings seem to have been made in Ceylon and no Cape plants are among them.

137. Mimusops Kauki, Sp. 349 ..	M. Kauki, *L.*

The specimen (vol. i. fol. 35) is certainly not the plant whose native name is quoted from Hermann's Mus. Zeyl. by Linnæus, which is 138. *Mimusops Elengi*, of which the specimens are in the herbarium (vol. ii. fol. 40). It is indeed not recorded at all in its place in the Mus. Zeyl., where it should appear on p. 7. This renders it doubtful whether it was collected in Ceylon. It appears to me to correspond pretty closely with Javan specimens of the tree still known as *M. Kauki*, with long petioles and a pale under surface to the leaves, and not with *M. indica*, to which Mr. Bentham (Fl. Austral. iv. p. 285) has referred it. *M. Kauki* I have never seen in Ceylon, either wild or cultivated; but it may well have existed there in gardens in Hermann's time. The Fl. Brit. Ind. (iii. p. 549) gives Burma, Malacca, and Malaya generally; as well as N. Australia, whence R. Brown (Prod. Fl. Nov. Holl. p. 531) records it, referring to Hermann's specimen as authority for the name.

138. Mimusops Elengi, Sp. 349 ..	M. Elengi, *L.*
139. Jambolifera pedunculata, Sp. 349	Acronychia laurifolia, *Blume* [see also 185].

There is no doubt as to the correctness of this identification of the *specimens* (vol. ii. fol. 82); though Linnæus has mixed up this with no. 185 in his numbering of other specimens in vol. ii. fol. 38, and has transposed their native names in 'Fl. Zeylan.' Indeed it appears that he subsequently in his later works ended by confirming the transposition; and possibly it would be practically correct to consider that the numbers in the herbarium are to be disregarded rather than the text. Thus in Mant. ii. Linnæus quotes Plukenet, tab. 174. fig. 2, for this, which clearly represents 185. *Eugenia Jambolana* (see that number). Vahl, however, has rightly described and figured (Symbolæ, iii. p. 52, t. 61) *Acronychia laurifolia* as *Jambolifera pedunculata*, L.

140. Allophylus zeylanicus, Sp. 348.	A. zeylanicus, *L.*
141. Ptelea viscosa, Sp. 118 (Dodonæa viscosa, Mant. ii. 149).	Dodonæa viscosa, *L.*
142. Cardiospermum Halicacabum, Sp. 366	C. Halicacabum, *L.*
143. Paullinia asiatica, Sp. 365....	Toddalia aculeata, *Pers.*
144. Michelia Champaca, Sp. 536.	M. Champaca, *L.*
145. Laurus Cinnamomum, Sp. 369.	Cinnamomum zeylanicum, *Blume.*
146. Laurus Cassia, Sp. 369......	Litsea zeylanica, *Nees*; and C. zeylanicum, *Blume* (*wild form*).

The *Laurus Cassia* of Linnæus has nothing to do botanically with the *Cinnamomum Cassia*, Blume, of S.W. China, now known to be the source of the Cassia of commerce. The specimens in Hb. Hermann show Linnæus's species to be founded on two plants,—one the common wild form of the true Cinnamon, and the other a Laurineous tree, also called a wild Cinnamon by the natives, *Litsea zeylanica*, Nees. (See also Wight in Hook. Journ. Bot. 1840, p. 336.)

147.	Bauhinia tomentosa, Sp. 375.	B. tomentosa, *L.*
148.	Bauhinia acuminata, Sp. 375.	B. acuminata, *L.*
149.	Cassia Fistula, Sp. 377	C. Fistula, *L.*
150.	Cassia Sophera, Sp. 379	C. Sophera, *L.*
151.	Cassia auriculata, Sp. 379.	C. auriculata, *L.*
152.	Cassia Tora, Sp. 376	C. Tora, *L.*
153.	Cassia absus, Sp. 376.	C. absus, *L.*
154.	Cassia mimosoides, Sp. 379	C. mimosoides, *L.*
155.	Guilandina Moringa, Sp. 381.	Moringa pterygosperma, *Gaertn.*
156.	Guilandina Bonducella, Sp. ed. ii. 545	Cæsalpinia Bonducella, *Flem.*

C. Bonducella has not been recently recorded for Ceylon, though *C. Bonduc* is common.

157.	Cæsalpinia Crista, Sp. 380 (Guilandina Bonduc, Mant. ii. 378).	Cæsalpinia Nuga, *Ait.*
158.	Cæsalpinia Sappan, Sp. 381	C. Sappan, *L.*
159.	Poinciana pulcherrima, Sp. 380.	P. pulcherrima, *L.*
160.	Adenanthera pavonina, Sp. 384.	A. pavonina, *L.*
161.	Melia Azadirachta, Sp. 385	Azadirachta indica, *A. Juss.*
162.	Melia Azedarach, β. sempervirens, Sp. 385.	M. Azederach, *L.*
163.	Sophora tomentosa, Sp. 373.	S. tomentosa, *L.*
164.	Sophora heptaphylla, Sp. 373.	S. heptaphylla, *L.*, and Derris sinuata, *Benth.*
165.	Anacardium occidentale, Sp. 383	A. occidentale, *L.*
166.	Cynometra cauliflora, Sp. 382.	*No specimen.*
167.	Cynometra ramiflora, Sp. 382.	*No specimen.*

166 and 167. There are drawings referred to these numbers which are not determinable, and seem to have been partly made up from *Averrhoa.*

168.	Tribulus lanuginosus, Sp. 387.	T. terrestris, *L.* (*drawing*).
169.	Jussiæa repens, Sp. 388.	J. repens, *L.*
170.	Jussiæa erecta, Sp. 388	J. suffruticosa, *L.*, var.
171.	Melastoma malabathricum, Sp. 390	M. malabathricum, *L.*
172.	Melastoma aspera, Sp. 391	Osbeckia aspera, *Blume.*
173.	Melastoma octandra, Sp. 391.	Osbeckia octandra, *DC.*
174.	Triumfetta Bartramia, Sp. ed. ii. 638	T. rhomboidea, *Jacq.*

The name *T. Bartramia*, L., has been abandoned by botanists as apparently comprehending more than one species; but the present common Eastern weed is certainly that mainly intended by the author of the name.

175. Schinus Limonia, Sp. 389 (Limonia acidissima, Sp. ed. ii. 554)	Feronia Elephantum, *Corr.*

The specimens are in leaf only, without flowers or fruit; but are sufficient to show that the plant is the common Wood-apple of Ceylon, *Feronia Elephantum*, the "Diwul" of the Singhalese, as rightly labelled by Hermann. But most of the synonyms given by Linnæus refer to some small-fruited species of Aurantiaceæ. The plant to which Linnæus's name has been generally applied is *L. crenulata*, Roxb., and does not occur in Ceylon. Roxburgh's name for this must stand instead of Linnæus's.

176. Bannisteria benghalensis, Sp. 427	Hiptage Madablota, *Gaertn.*
177. Averrhoa Bilimbi, Sp. 428	A. Bilimbi, sp. 428.
178. Averrhoa Carambola, Sp. 428.	A. Carambola, *L.*
179. Averrhoa acida, Sp. 428	A. Carambola, *L.*, var. ? (*drawing*).
180. Oxalis sensitiva, Sp. 434	Biophytum sensitivum, *DC.*
181. Rhizophora conjugata, Sp. 443.	Bruguiera gymnorrhiza, *Lam.* (*drawing*).

Hermann's figure is the whole foundation for Linnæus's *R. conjugata*, yet there can be no doubt that it is *Bruguiera gymnorrhiza*; but it would be very undesirable to change so long established a name. The specimens named *R. conjugata* in Linnæus's own herbarium are of some very different plant from either of these species.

182. Myrtus zeylanica, Sp. 472	Eugenia zeylanica, *Wight.*
183. Myrtus caryophyllata, Sp. 472.	Eugenia caryophyllæa, *Wight.*
184. Myrtus androsæmoides, Sp. 472.	Eugenia cordifolia, *Wight.*
185. Myrtus Cumini, Sp. 471	Eugenia Jambolana, *Lam.* [see also 139].

See the note on 139. The specimens not mixed up with this other number are in vol. i. fol. 45, and are *E. Jambolana.*

186. Myrtus Pimenta, Sp. 472	*No specimen.*
187. Eugenia malaccensis, Sp. 470.	*No specimen.*
188. Eugenia Jambos, Sp. 470	E. Jambos, *L.*
189. Eugenia uniflora, Sp. 470	E. malaccensis, *L.*, var. (*drawing*).

E. uniflora of Linnæus is a curious mixture. Hermann's figures show a large-flowered species with usually solitary sessile flowers; apparently a slight variety of *E. malaccensis.* But

Linnæus quotes also Micheli's figure (Nov. Gen. t. 108) of the very different species from S. America, now semi-naturalized in parts of India, *E. Michelii*, Lam. Linnæus's name should be abandoned.

190. Eugenia acutangula, Sp. 471 . .	Barringtonia acutangula, *Gaertn.*
191. Eugenia racemosa, Sp. 471 . .	Barringtonia racemosa, *Blume.* (*drawing*).
192. Psidium Guajava, Sp. 470 . .	P. Guyava, *L.*
193. Nymphæa Nelumbo, Sp. 511.	Nelumbium speciosum, *Willd.*
194. Nymphæa Lotus, Sp. 511. . . .	N. Lotus, *L.*
195. Cambogia Gutta, Sp. ed. ii. 728	Garcinia Morella, *Desr.* (*the drawing is* G. Cambogia, *Desr.*).

The specimens are leaves of the true Gamboge-tree, called "Gokatu" or "Kana-goraka" by the Singhalese, as rightly noted by Hermann, and the *G. Morella*, Desr. But the drawings show the common "Goraka," *G. Cambogia*, Desr., with its edible sulcate fruit. (See also Graham in Hook. Comp. Bot. Mag. ii. pp. 193–200.)

196. Euphorbia Tirucalli, Sp. 452. .	*No specimen.*
197. Euphorbia hirta, Sp. 454	E. hirta, *L.*
198. Euphorbia thymifolia, Sp. 454.	E. thymifolia, *L.*
199. Euphorbia antiquorum, Sp. 450	*No specimen.*
200. Euphorbia neriifolia, Sp. 451. .	*No specimen.*
201. Calophyllum Inophyllum, Sp. 513	C. Inophyllum, *L.*
202. Calophyllum Calaba, Sp. 514.	C. Burmanni, *Wight.*

The name *C. Calaba* has been generally abandoned for this Eastern species, to which it originally belongs, in consequence of Jacquin having figured in 1763 (Hist. Select. Strip. Amer. t. 165) as Linnæus's species the Martinique plant, to which Plumier first gave the generic name *Calaba*, taken from the Caribbee name. Linnæus (Sp. Plant. ed. ii. 732) accepted Jacquin's determination, and hence makes his own species to include both the E. and W.-Indian plants. The name should not be maintained for either.

203. Mesua ferrea, Sp. 515	M. ferrea, *L.*
204. Vateria indica, Sp. 515	*No specimen?*

Dryander has doubtfully referred to this some leaves in the Herbarium, vol. iv. fol. 27. These are certainly not *Vateria*, but possibly *Pericopsis Mooniana*. The specimen referred to by Linnæus "in tomo quarto" may possibly be the leaves at fol. 36, which appear to be those of some Dipterocarp, though not *Vateria*. (See also Dyer in Fl. Brit. India, i. p. 313.)

205. Delima sarmentosa, Sp. ed. ii. 736	D. sarmentosa, *L.*
206. Elæocarpus serrata, Sp. 515	E. serratus, *L.*

The 'Flora of Brit. India' (i. p. 401) does not give *E. serratus*, L., as a Ceylon species, and refers (p. 402) Thwaites's specimens to *E. cuneatus*, Wight. I look upon the latter as a slight variety of *E. serratus* merely. Hermann's six specimens of the "Weralu," a very common little tree the fruit of which is known as "Wild Olives" by the English, show the usual variety in form of the leaves—oval, or obovate-oval, or oblong-lanceolate.

207. Microcos paniculata, Sp. 514 (Grewia Microcos, Syst. ed. xii. 602)	Grewia Microcos, *L.*
208. Microcos lateriflora, Sp. 514 (Grewia asiatica, Mant. i. 122).	Grewia asiatica, *L.*
209. Ochna Jabotapita, Sp. 513 (O. squarrosa, Sp. ii. 731)	O. squarrosa, *L.*
210. Capparis zeylanica, Sp. ii. 720.	C. zeylanica, *L.*, and C. horrida, *L. f.*
211. Cratæva Tapia, Sp. 444	(? *drawing*).

Linnæus says this is among Hermann's drawings; but I cannot trace it there.

212. Cratæva Marmelos, Sp. 444	Ægle Marmelos, *Corr.* (*drawing*).
213. Corchorus olitorius, Sp. 529	C. acutangulus, *Lam.*

It is remarkable that all the specimens are *C. acutangulus*; but Linnæus no doubt included this under *C. olitorius* as one species.

214. Corchorus capsularis, Sp. 529.	C. capsularis, *L.* (*drawing*).
215. Mimosa cinerea, Sp. 520	Dichrostachys cinerea, *Wight & Arn.*
216. Mimosa pennata, Sp. 522	Acacia pennata, *Willd.*
217. Mimosa cæsia, Sp. 522	Acacia cæsia, *Willd.*
218. Mimosa bigemina, Sp. 517	Pithecolobium bigeminum, *Benth.*
219. Mimosa Entada, Sp. 518	Entada scandens, *Benth.*
220. Bombax pentandrum, Sp. 511.	*No specimen.*
221. Bombax Ceiba, Sp. 511	*No specimen.*
222. Bombax religiosa, Sp. 512 (B. gossypinum, Syst. ed. xii. 457)	Cochlospermum Gossypium, *DC.*
223. Stratiotes alismoides, Sp. 535.	*No specimen.*
224. Uvaria zeylanica, Sp. 536	U. zeylanica, *L.*
225. Anona asiatica, Sp. 537	Anona squamosa, *L.* (*drawing*).

There is no *Anona* native in Asia. Hermann's drawings represent the Custard-apple, *A. squamosa*; but the name "*Anon. sylvestris*, &c." and the native name given in Mus. Zeyl. p. 59 are to be referred to *Morinda citrifolia*. The confusion of the two plants has arisen from the outward similarity of their fruits. A twig with leaves in the herbarium (vol. iv. fol. 80) appears to be the original of Linnæus's description, though numbered by him 224; and is probably *A. squamosa.*

226.	Atragene zeylanica, Sp. 542 ..	Naravelia zeylanica, *DC.*
227.	Phlomis zeylanica, Sp. 586 ..	Leucas zeylanica, *R. Br.*
228.	Ocymum frutescens, Sp. 597 (Mentha perilloides, Syst. ed. xii. 736)	Pogostemon Heyneanus, *Benth.*

Linnæus's *Ocymum frutescens* has been erroneously referred, in Fl. Brit. Ind. iv. p. 646, to *Perilla ocymoides*, L., and his *Mentha perilloides* by Bentham (DC. Prod. xii. p. 127) to *Hyptis pectinata*, Poir.; neither of these is a Ceylon plant. Hermann's specimens are the wild Patchouli plant, "Gan̥-kollan̥-kola" of the Singhalese, *Pogostemon Heyneanus*, Benth. Moon (Cat. Ceylon Plants, p. 44) rightly refers *Mentha perilloides* to this plant.

229.	Ocymum menthoides, Sp. 598.	Geniosporum prostratum, *Benth.*

The *Ocymum menthoides* of Linnæus has also been often misunderstood. The form of *Geniosporum prostratum* with a slender erect stem is that especially intended by him, as is seen by his description in Fl. Zeyl., and his reference to Burman's excellent figure in Thes. Zeyl. t. 70. fig. 2[*]. This same little form is again figured in N. Burman's Fl. Indica, t. 39. fig. 1, under the name of *Rhinanthus indica*; but is very different from Linnæus's plant of the same name, for which see no. 238.

230.	Gmelina asiatica, Sp. 626	Gmelina asiatica, *L.*
231.	Volkameria inermis, Sp. 637 ..	Clerodendrum inerme, *R. Br.*
232.	Clerodendrum infortunatum, Sp. 637	C. infortunatum, *L.*
233.	Barleria Prionitis, Sp. 636	B. Prionitis, *L.*
234.	Ruellia ringens, Sp. 635	R. ringens, *L.*
235.	Ruellia antipoda, Sp. 635	Bonnaya veronicæfolia, *Spreng.*

Linnæus referred to this also a plant from Barbadoes figured by Plukenet; whence his specific name.

236.	Bignonia indica, Sp. 603	Oroxylum indica, *Vent.* (*drawing*).
237.	Sesamum orientale, Sp. 634 ..	*No specimen.*
238.	Rhinanthus indica, Sp. 603 ..	Centranthera procumbens, *Benth.*

This name of Linnæus's is quoted for *Geniosporum elongatum* in Fl. Brit. Ind. iv. p. 610; but the specimens are *Centranthera procumbens*, and Linnæus's description is very good for that plant.

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[*] But Bentham, who saw Burman's specimen, says it is *G. elongatum* (DC. Prod. xii. p. 45); and the figure is therefore quoted under that species in Fl. Brit. Ind.

239.	Cleome gynandra, Sp. 671	Gynandropsis pentaphylla, *DC.*
240.	Cleome icosandra, Sp. 672	*No specimen.*
241.	Cleome viscosa, Sp. 672	C. viscosa, *L.*
242.	Cleome dodecandra, Sp. 672	C. viscosa, *L.*, var. (*drawing*).
243.	Cleome monophylla, Sp. 672.	C. monophylla, *L.*
244.	Waltheria indica, Sp. 673	W. indica, *L.*
245.	Melochia pyramidata, Sp. 674.	*No specimen.*
246.	Melochia corchorifolia, Sp. 675	*No specimen.*
247.	Melochia concatenata, Sp. 675	M. corchorifolia, *L.*, var.
248.	Connarus monocarpus, Sp. 675	C. monocarpus, *L.*
249.	Hugonia Mystax, Sp. 677	H. Mystax, *L.*, and Ancistrocladus Vahlii, *Arn.*
250.	Pentapetes suberifolia, Sp. 698	Pterospermum suberifolium, *Lam.*
251.	Sida periplocifolia, Sp. 684	Wissadula zeylanica, *Med.*
252.	Sida rhombifolia, Sp. 684	S. rhombifolia, *L.*
253.	Sida alnifolia, Sp. 684	S. rhombifolia, *L.*, var. ?, and S. cordifolia, *L.*

The specimens are very indifferent.

254.	Sida spinosa, sp. 683	S. spinosa, *L.*
255.	Malva tomentosa, sp. 687	Sida cordifolia, *L.* (*drawing*).

This is indeterminable; for though the drawing probably represents *Sida cordifolia*, the specimen (vol. iv. fol. 3) appears to be a fragment without flowers of some Labiate plant.

256.	Urena lobata, Sp. 692	U. lobata, *L.*
257.	Urena sinuata, Sp. 692	U. sinuata, *L.*
258.	Hibiscus populneus, Sp. 694	Thespesia populnea, *Corr.*
259.	Hibiscus tiliaceus, Sp. 694	H. tiliaceus, *L.*
260.	Hibiscus Rosa-sinensis, Sp. 694	H. Rosa-sinensis, *L.*
261.	Hibiscus Abelmoschus, Sp 696	H. Abelmoschus, *L.* (*drawing*).
262.	Hibiscus Sabdariffa, Sp. 695	*No specimen.*
263.	Hibiscus ficulneus, Sp. 695	*No specimen.*
264.	Hibiscus Sabdariffa, β, Sp. 695	H. surattensis, *L.*
265.	Hibiscus vitifolius, Sp. 696	H. vitifolius, *L.*
266.	Hibiscus zeylanicus, Sp. 697.	Pavonia odorata, *Willd.*

Hermann's specimen is certainly *P. odorata*, Willd., and not *P. zeylanica*, Cav., as generally named.

267.	*Not named*	Gossypium herbaceum, *L.*
268.	Polygala ciliata, Sp. 705	Salomonia oblongifolia, *DC.*

The specimens quite correspond with *S. oblongifolia*, DC., having oblong-oval leaves, very slightly cordate at the base, and with a few large marginal bristles. As mentioned by Mr. W. Ferguson in Thw. Enum. Pl. Zeyl. p. 22, they agree with C. P. 1086. In Fl. Brit. Ind. (i. p. 207), however, these same specimens are said to be identical with Arnott's *S. cordata*, which has broader leaves, and is C. P. 2906. But I think these are scarcely more than varieties of one species.

269. Polygala triflora, Sp. 705	P. glaucoides, *L.*, var.

P. triflora, L., is considered a variety of *P. chinensis* in Fl. Brit. Ind. i. p. 204; but it has very short racemes, and is better placed as a variety under *P. glaucoides*, L. It agrees with Thwaites's *P. arvensis*, var. β (Enum. p 400), which is C. P. 1083, and *P. glaucoides*, var. 2, of the Fl. Brit. Ind.

270. Polygala glaucoides, Sp. 705.	P. glaucoides, *L.*
271. Aspalathus indica, Sp. 712	Indigofera aspalathoides, *Vahl.*
272. Indigofera hirsuta, Sp. 751	I. hirsuta, *L.*
273. Indigofera tinctoria, Sp. 751.	I. tinctoria, *L.*
274. Indigofera glabra, Sp. 751	I. pentaphylla, *L.*

The leaves are hairy. This seems quite the same as *I. pentaphylla*, L., which is a later name.

275. Erythrina Corallodendrum, sp. 706	E. indica, *Lam.* (*drawing*).

Linnæus's *E. Corallodendrum* includes more than one species, and cannot be maintained.

276. Crotalaria retusa, Sp. 715	C. retusa, *L.*
277. Crotalaria verrucosa, Sp. 715.	C. verrucosa, *L.*
278. Crotalaria laburnifolia, Sp. 715	C. laburnifolia, *L.*
279. Cytisus Cajan, Sp. 739	Cajanus indicus, *Spreng.*
280. Phaseolus Max, Sp. 725	P. Max, *L.*
281. Phaseolus radiatus, Sp. 725	*No specimen.*
282. Dolichos scarabæoides, Sp. 726	Atylosia scarabæoides, *Benth.*
283. Clitoria ternatea, Sp. 753	C. ternatea, *L.*
284. Glycine Abrus, Sp. 753 (Abrus precatorius, Syst. ed. xii. 472)	Abrus precatorius, *L.*
285. Trigonella indica, Sp. 778	Rothia trifoliata, *Pers.*
286. Hedysarum triquetrum, Sp. 746	Desmodium triquetrum, *DC.*
287. Hedysarum vaginale, Sp. 746.	Alyssicarpus vaginalis, *DC.*
288. Hedysarum nummularifolium, Sp. 746	Indigofera echinata, *Willd.*
289. Hedysarum strobiliferum, Sp. 746	Flemingia strobilifera, *R. Br.*
290. Hedysarum maculatum, Sp. 746	*No specimen.*
291. Hedysarum diphyllum, Sp. 747	Zornia diphylla, *Pers.*
292. Hedysarum pulchellum, Sp. 747	Desmodium pulchellum, *Benth.*
293. Hedysarum umbellatum, Sp. 747	Desmodium umbellatum, *DC.*
294. Hedysarum heterocarpum, Sp. 747	Desmodium heterocarpum, *DC.* (D. polycarpon, *DC.*).
295. Hedysarum viscidum, Sp. 747.	Pseudarthria viscida, *Wight & Arn.*
296. Hedysarum biarticulatum, Sp. 747	Desmodium biarticulatum, *Benth.*

297. Hedysarum triflorum, Sp. 747	Desmodium triflorum, *DC.*
298. Æschynomene aspera, Sp. 713	A. aspera, *L.*
299. Cracca villosa, Sp. 752	Tephrosia villosa, *Pers.*
300. Cracca maxima, Sp. 752	Tephrosia purpurea, *Pers.*, var.
301. Cracca purpurea, Sp. 752	Tephrosia purpurea, *Pers.*
302. Cracca tinctoria, Sp. 752	Tephrosia tinctoria, *Pers.*
303. Cracca senticosa, Sp. 752	Tephrosia senticosa, *Pers.*

Hermann's are the only specimens of this species I have seen from Ceylon; nor did Thwaites ever meet with it. The pods are only sparingly pilose, much less so than in *T. pentaphylla*, Grah., from Burma. (See also Wight and Arnott, Prod. Fl. Ind. Or. p. 212). One of Hermann's specimens consists of leaves only, very luxuriant, and looking as if from a cultivated plant.

304. Citrus Aurantium, Sp. 782	*No specimen.*
305. Cacalia sonchifolia, Sp. 835	Emilia sonchifolia, *DC.*
306. Eupatorium zeylanicum, Sp. 837	Vernonia zeylanica, *Less.*
307. Gnaphalium indicum, Sp. 852	Amphidoxa gnaphalodes, *DC.*

This is the other case in which Linnæus has taken a Cape plant for a Ceylon one. The specimens are *Amphidoxa gnaphalodes*, DC.; but Linnæus has added a reference to a figure of a Madras plant in Plukenet (*t.* 187. fig. 5), which may perhaps represent the plant now universally called *Gnaphalium indicum*. Subsequently he seems to have discovered that Hermann's specimens were from the Cape, as he adds in Sp. Plant. ii. p. 1200, "Cap. B. Spei," where *G. indicum*, auct., however, does not occur. It would thus seem that this common Eastern tropical weed cannot retain the name by which it has been so long known, as there is no reason to suppose it to be the *G. indicum* intended by Linnæus *. This weed, *G. indicum*, auct. (*non* L.), is a very recent introduction to Ceylon; Thwaites remarks (Enum. p. 422) that he had never seen it; and I doubt if it were to be found much before 1882, when I first noticed it. It had then become a noticeable weed in some of the coffee-estates in the hills, and went among the planters by the inappropriate name of "Wild Mignonette." Since then it has rapidly spread in the estates.

308. Verbesina pseudo-Acmella, Sp. 901 (Spilanthes pseudo-Acmella, Syst. ed. xiii. 610)	Wedelia biflora, *DC.* ?
309. Verbesina Acmella, Sp. 901 (Spilanthes Acmella, Syst. ed. xiii. 610)	Blainvillea latifolia, *DC.* (*The drawing* S. Acmella, *L.*).

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* There is no specimen of *G. indicum*, L., in Linnæus's own herbarium.

308 and 309. Both these species of Linnæus have been usually referred to *Spilanthes Acmella*, L.; but neither of Hermann's specimens are of that plant. The drawing, however, of 309 represents *S. Acmella*; and the figure of Plukenet's quoted is also for that plant, which, in spite of the specimens, is probably what was intended. But 308, *V. pseudo-Acmella*, is almost certainly young *Wedelia biflora*; and with this species Plukenet's figure quoted by Linnæus also corresponds.

310. Verbesina Lavenia, Sp. 902 ..	Adenostemma viscosum, *Forst.*
311. Verbesina calendulacea, Sp. 902	Wedelia calendulacea, *Less.*
312. Sphæranthus indicus, Sp. 927.	S. indicus, *L.*
313. Lobelia Plumieri, Sp. 929 ..	Scævola Kœnigii, *Vahl* (*drawing*).
314. Impatiens oppositifolia, Sp. 937	I. oppositifolia, *L.*
315. Impatiens triflora, Sp. 938 ..	Hydrocera triflora, *Wight & Arn.*
316. Impatiens cornuta, Sp. 937 ..	I. Balsamina, *L.*, var.

I. cornuta, L., seems a well-marked variety at least of *I. Balsamina*, and is quite wild in Ceylon. The leaves are lanceolate and attenuate at the base, and the spur of the rather small flower is very long and slender. Linnæus gives a good description of Hermann's specimens, and quotes with approval the excellent figure in Thes. Zeylan. t. 16. f. 1.

317. Viola enneasperma, Sp. 937 ..	Ionidium suffruticosum, *Ging.*, var.

This is a diffuse form merely of *I. suffruticosum* with the leaves nearly entire.

318. Viola suffruticosa, Sp. 937 ..	Ionidium suffruticosum, *Ging.*
319. Orchis strateumatica, Sp. 943.	Zeuxine sulcata, *Lindl.*
320. Orchis cubitalis, Sp. 940	Habenaria cubitalis, *R. Br.*
321. Nepenthes distillatoria, Sp. 955	N. distillatoria, *L.*
322. Pistia Stratiotes, Sp. 963	P. Stratiotes, *L.*
323. Aristolochia indica, Sp. 960 ..	A. indica, *L.*
324. Grewia orientalis, Sp. 964....	G. orientalis, *L.*
325. Arum divaricatum, Sp. 966 ..	*No specimen.*
326. Arum trilobatum, Sp. 965	Typhonium trilobatum, *Schott.*
327. Arum macrorhizum, Sp. 965.	Alocasia macrorrhiza, *Schott.* (*drawing*).
328. Dracontium spinosum, Sp. 967	Lasia spinosa, *Thw.* (*drawing*).
329. Pothos scandens, Sp. 968	P. scandens, *L.*
330. Coix Lacryma-Jobi, Sp. 972..	Coix Lacryma, *L.*
331. Phyllanthus Niruri, Sp. 981 ..	P. Niruri, *L.* (*drawing*).
332. Phyllanthus urinaria, Sp. 982.	P. urinaria, *L.*
333. Phyllanthus Emblica, Sp. 982.	P. distichus, *Müll. Arg.* (*drawing.*)

There is no specimen. The plant figured is not the wild "Nelli" of Ceylon, *P. Emblica*, but the cultivated *P. distichus* (*Cicca disticha*).

334. Tragia Mercurialis, Sp. 980	*No specimen.*
335. Tragia Chamælæa, Sp. 981	Sebastiana Chamælæa, *Müll. Arg.*
336. Urtica interrupta, Sp. 985	Fleurya interrupta, *Gaud.*
337. Morus indica, Sp. 986	M. indica, *L.*
338. Amaranthus spinosus, Sp. 991.	A. spinosus, *L.* (*drawing*).
339. Ricinus communis, Sp. 1007.	R. communis, *L.* (*drawing*).
340. Tragia involucrata, Sp. 980	T. involucrata, *L.*
341. Acalypha indica, Sp. 1003	A. indica, *L.*
342. Acalypha virginica, Sp. 1003.	*No specimen.*
343. Croton Tiglium, Sp. 1004	C. Tiglium, *L.*
344. Croton lacciferum, Sp. 1005	C. lacciferum, *L.*
345. Croton aromaticum, Sp. 1005.	C. aromaticum, *L.*
346. Croton moluccanum, Sp. 1005	Givotia rottleriformis, *Griff.* ?

I do not feel sure as to the determination of this specimen, but believe it to be *Givotia.* It is certainly not *Mallotus moluccanus*, Müll. Arg., to which that author says (DC. Prod. xv. 2, p. 958) the specimen of *Croton molucc.* in "Hb. Linn." is to be referred.

347. Croton spinosum, sp. 1005	Jatropha glandulifera, *Roxb.* (*drawing*).

Hermann's drawing is very unsatisfactory; but I think it represents *J. glandulifera*, a not uncommon introduced weed in Ceylon.

348. Jatropha moluccana, Sp. 1006.	Aleurites triloba, *Forst.*

This is the tree so universally cultivated in the low moist districts of Ceylon for the oil of its seeds, which is, however, now giving way to Kerosine.

349. Sterculia fœtida, Sp. 1008	S. fœtida, *L.*
350. Sterculia Balanghas, Sp. 1007.	S. Balanghas, *L.*
351. Momordica Charantia, Sp. 1009	*No specimen.*
352. Momordica Luffa, Sp. 1009	Luffa acutangula, *Roxb.* (*drawing*).
353. Bryonia palmata, Sp. 1012	B. lacinosa, *L.*

The specimen is very bad, but seems to be nothing more than *B. laciniosa*; but Linnæus's description and the native name refer to *Modecca palmata.*

354. Bryonia cordifolia, Sp. 1012	Mukia scabrella, *Arn.*

There are only leaves, which appear to be those of the ordinary form of *Mukia scabrella.*

355. Bryonia laciniosa, Sp. 1013	*No specimen.*
356. Cucumis maderaspatanus, Sp. 1012	Mukia scabrella, *Arn.*, var.

The specimens are of a nearly glabrous-leaved form of *Mukia* *scabrella*. Cogniaux (Mon. Cucurb. p. 623) calls this species *Melothria maderaspatana*.

357. Antidesma Alexiteria, Sp. 1027	A. Bunius, *Spreng.*, A. zeylanicum, *Lam.*, and A. Ghæsambilla, *Gaertn.*

As shown by the numerous specimens in the herbarium, the name *A. Alexiteria*, L., cannot rightly be restricted to *A. zeylanicum*, Lam., as I have applied it in 'Cat. Plants Ceylon,' p. 81.

358. Dioscorea sativa, Sp. 1033 ..	Tinospora cordifolia, *Miers.*

Linnæus must have been well acquainted with *D. sativa*; and his reference to it of these specimens of the very different "Rasakinda," *Tinospora cordifolia*, must be regarded as an inadvertence.

359. Dioscorea bulbifera, Sp. 1033.	*No specimen.*
360. Dioscorea alata, Sp. 1033	D. alata, *L.*?

Only leaves represent this; and I cannot feel sure of their identification with *D. alata*, which is a cultivated Yam in Ceylon.

361. Dioscorea oppositifolia, Sp. 1033	D. oppositifolia, *L.*
362. *Not named*	Cyclea Burmanni, *Miers.*

In the 'Flora Zeylanica' this is referred from its facies to *Dioscorea*; but it was not taken up by Linnæus in his subsequent works under that or any other genus.

363. Dioscorea pentaphylla, Sp. 1032	D. pentaphylla, *L.* (*drawing*).
364. Smilax zeylanica, Sp. 1029 ..	S. zeylanica, *L.*
365. Carica Papaya, Sp. 1036	*No specimen.*
366. Clutia Eluteria, Sp. 1042	*No specimen.*
367. Clutia retusa, Sp. 1042	Bridelia retusa, *Spreng.*
368. Musa paradisiaca, Sp. 1043 ..	M. paradisiaca, *L.*
369. Celtis orientalis, Sp. 1044....	Trema orientalis (*L.*).
370. *Not named*	*No specimen.*
371. Parietaria zeylanica, Sp. 1052 (Urtica alienata, Syst. ed. xii. 622)	Pouzolzia zeylanica, *Gaud.*, var.

The *Urtica alienata* of Linn. is rightly regarded by Weddell as a variety only of *Pouzolzia indica*; it is the *P. zeylanica*, J. J. Benn. (Pl. Jav. Rar. p. 67), who quotes Hermann's specimen.

372. Ficus religiosa, Sp. 1059	F. religiosa, *L.*
373. Osmunda zeylanica, Sp. 1063.	Helminthostachys zeylanica, *Hook.* (*drawing*).
374. Ophioglossum scandens, Sp. 1063	Lygodium scandens, *Sw.*
375. Ophioglossum flexuosum, Sp. 1063	Lygodium flexuosum, *Sw.*

376. Acrostichum siliquosum, Sp. 1070	Ceratopteris thalictroides, *Brong.*

This is nothing more than a starved specimen of 377 with good fructification.

377. Acrostichum thalictroides, Sp. 1070	Ceratopteris thalictroides, *Brong.*
378. Acrostichum heterophyllum, Sp. 1067	Drymoglossum heterophyllum (*L.*)[*] (D. piloselloides, *Presl*).
379. Acrostichum digitatum, Sp. 1068	Schizæa digitata, *Sw.*
380. Acrostichum lanceolatum, Sp. 1067	Niphobolus lanceolatus (*L.*)[*] (Polypodium adnascens, *Sw.*).
381. Adiantum caudatum, Mant. 308	A. caudatum, *L.*
382. Polypodium quercifolium, Sp. 1087	P. quercifolium, *L.*
383. Polypodium auriculatum, Sp. 1088	Nephrolepis cordifolia, *Presl.*

As this is the type of *P. auriculatum*, L., the name *Nephrolepis auriculata* should, in accordance with the principles which are held to govern the nomenclature of Ferns, take the place of *N. cordifolia.* Linnæus's plant has generally been taken to be *Polystichum auriculatum*, Presl, which perhaps Burman's wretched figure quoted by Linnæus may represent.

384. Polypodium Speluncæ, Sp. 1093	Microlepia Speluncæ, *Moore.*
385. Trichomanes adiantoides, Sp. 1099	Asplenium falcatum, *Lam.* ?

The determination of this is somewhat doubtful; the specimen is without fructification.

386. Lycopodium Phlegmaria, Sp. 1101	L. Phlegmaria, *L.*
387. Lycopodium cernuum, Sp. 1103	L. cernuum, *L.*
388. Lycopodium ornithopodioides, Sp. 1105	Selaginella ornithopodioides (*L.*)[*] (S. integerrima, *Spring*).

Hermann's plant is the very common little species in the South of Ceylon, which Baker (Journ. Bot. xxii. p. 88) refers to *S. integerrima*, Spring, adding that it is the *L. ornithopodioides* of the Linnean herbarium. I think it should keep this latter specific name, though Linnæus has confused his species by quoting for it the figure in Dillenius's 'Hist. Musc.,' which that writer considered to be Hermann's Ceylon plant, but which represents a different species[*]. Baker (*l. c.* xxi. p. 46), however, retains the name *S. ornithopodioides* for this latter species, as was done by Spring also.

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[*] It is customary in Fern-nomenclature to retain the earliest specific name under whatever genus it may have been published.

389. Fucus natans, Sp. 1160	Sargassum polyphyllum, *Turn.*
390. Phœnix dactylifera, Sp. 1188.	*No specimen.*
391. Cocos nucifera, Sp. 1188	C. nucifera, *L.* (*drawing*).
392. Areca Cathecu, Sp. 1189	Areca Catechu, *L.* (*drawing*).
393. Cycas circinalis, Sp. 1188	Cycas circinalis, *L.* (*drawing*).
394. Corypha umbraculifera, Sp. 1187	*No specimen.*
395. Borassus flabellifer, Sp. 1187 (B. flabelliformis, Syst. Veg. ed. xiii. 829)	*No specimen.*
396. Caryota urens, Sp. 1189	Caryota urens, *L.* (*drawing*).
397. Elate sylvestris, Sp. 1189	*No specimen.*

Obscuræ.

398. Ophioxylon serpentinum, Sp. 1043.	O. serpentinum, *L.*
399. Verbena nodiflora, Sp. 21.	Lippia nodiflora, *Rich.* (*drawing*).
400. Knoxia zeylanica, Sp. 105	K. zeylanica, *L.*
401. Cyclamen indicum, Sp. 145	Cyclamen? (*drawing*).

I can make nothing of this extraordinary drawing, which appears to have puzzled Linnæus, who, however, gives a description of it. It seems to be a *Cyclamen*, and the native name "Urula," given by Hermann, which would mean "Pig's Yam," may be compared with the English name "Sow-bread." It may have been grown in some Dutchman's garden.

402. Ophiorhiza Mungos, Sp. 150.	O. Mungos, *L.*
403. Ribesioides[†]	Embelia Ribes, *Burm.*
404. Apocyno-nerium	Hunteria corymbosa, *Roxb.*
405. Jasmino-nerium	Carissa spinarum, *L.*
406. Phantis	Atalantia racemosa, *Wight & Arn.?*
407. Bannisterioides	Xanthophyllum flavescens, *Roxb.*
408. Santaloides.	Rourea santaloides, *Wight & Arn.*
409. Eugenioides	Symplocos spicata, *Roxb.*
410. Rhamnicastrum	Scolopia Gærtneri, *Thw.*
411. Mentha auricularia, Mant. 81.	Dysophylla auricularia, *Blume.*
412. Stæchado-mentha	Adenosma camphoratum, *Hook. f.*
413. Vitex trifolia, Sp. 638	*No specimen.*
414. Vitex Negundo, Sp. 638	*No specimen.*
415. Vitex pinnata, Sp. 638	Vitex altissima, *L. f.*, var.

V. pinnata, L. seems but a variety of *V. altissima*, with densely tomentose-pubescent leaves. The name is not taken up in Fl. Brit. Ind., but its equivalent in Fl. Zeylanica, "*Pistacio-vitex*," is quoted there (iv. p. 585) under *V. pubescens*, Vahl. If this be correct and the species maintained, *V. pinnata*, L., must supersede Vahl's name, and indeed *V. altissima*, L. f., also.

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[*] As Sir J. E. Smith determined by consulting Dillenius's own specimen at Oxford. (See his MS. note in Linnæus's own herbarium.)

[†] The names to which no reference is attached are those of the 'Flora Zeylanica' itself, not taken up by Linnæus in his subsequent systematic works.

416. Premna serratifolia, Mant. ii. 253	P. serratifolia, *L.*
417. Pterocarpus	Derris uliginosa, *Benth.*
418. Conyza anthelmintica, Sp. ed. ii. 1207	Vernonia anthelmintica, *Willd.*
419. Conyza cinerea, Sp. 863	Vernonia cinerea, *Less.*
420. Erigeroides	Epaltes divaricata, *Cass.*
421. Chrysanthemum indicum, Sp. 889	C. indicum, *L.*
422. Dracunculus	Amorphophallus campanulatus, *Bl.*
423. Hernandia Sonora, Sp. 981	H. peltata, *Meissn.* (*drawing*).
424. Filix	Pteris ensiformis, *Burm.*
425 Filix	Stenochlæna palustre (*Burm.*).
426. Filix	Nephrolepis acuta, *Presl?*
427. Polypodium unitum, Sp. ed. ii. 1548	Nephrodium unitum, *Schott.*
428. Filix	Pteris quadriaurita, *Retz.*
429. Filix	Gleichenia linearis, *C. B. Clarke.*

Dubiæ.

430. Highulhænda	Maba buxifolia, *Pers.*
431. Kaluhaburunghos	Cleistanthus acuminatus, *Müll. Arg.*
432. Nelughas	Mallotus fuscescens, *Müll. Arg.*
433. Samandura	Samadera indica, *Gaertn.*
434. Gædawaka	Chætocarpus castanocarpus, *Thw.*
435. Mindela	Barringtonia racemosa, *Blume?*
436. Hibiscoides	Coscinium fenestratum, *Colebr.*
437. Euonymoides	Gymnosporia emarginata, *Roth.*
438. Oxycoccoides	Ficus diversiformis, *Miq.*

The specimen consists of the creeping stems with small leaves such as are found clinging to rocks abundantly; this state bears a considerable outward resemblance to the Cranberry, which accounts for Linnæus's temporary name.

439. Wælmedya	Hippocratea indica, *Willd.*
440. Pedalium Murex, Sp. ed. ii. 829.	P. Murex, *L.* (*drawing*).
441. Rhus Cobbe, Sp. 267	Allophylus Cobbe, *Blume.*
442. Panaghas	Aglaia Roxburghiana, *Miq.*
443. Jurighas	Filicium decipiens, *Thw.*

Barbaræ.

These are numbered 444 to 573. Of none are there *specimens* in Hermann's herbarium except of:—

499. Oxalis	O. corniculata, *L.*

The following have, however, been named by Linnæus, and of two of them there are drawings:—

465. Andropogon Schœnanthus, Sp. 1046.	
468. Calamus Rotang, Sp. 325.	
471. Mangifera indica, Sp. 200.	
504. Euphorbia parviflora, Sp. ed. ii. 652	E. parviflora, *L.* (*drawing*).
505. Mimosa virgata, Sp. 519.	
511. Ocimum minimum, Sp. 597.	
520. Sida Abutilon, β, Sp. 685 (S. asiatica, Sp. ii. 964)	Abutilon asiaticum, *D. Don* (*drawing*).
534. Dolichos Soja, Sp. 727.	
539. Dolichos pruriens, Sp. ii. 1019.	
553. Hedysarum hamatum, Sp. ii. 1057.	
563. Amaranthus caudatus, Sp. 990.	
569. Xanthium Strumarium, Sp. 987.	

There are also *drawings* of the following:—

469. Cornus	Memecylum umbellatum, *Burm.*
490. Asclepias	Tylophora asthmatica, *Wight & Arn.*
491. Asclepias	Tylophora asthmatica, *Wight & Arn.*?
519. Sida	Abutilon asiaticum, *D. Don.*
533. Murtughas	Lagerstrœmia Flos-reginæ, *Retz.*
552. Trifolium	Melilotus parviflora, *Desf.*?

Annihilatæ.

These names occupy nos. 574 to 687. There are no specimens of any, and only one is figured:—

591. Modecca	Modecca palmata, *Lam.* (*drawing*).

There are also in the Herbarium specimens, neither named nor numbered, of the following Ceylon plants:—

Alyxia zeylanica, *Wight.*
Tylophora asthmatica, *Wight & Arn.*
Vandellia crustacea, *Benth.*
Striga euphrasioides, *Benth.*
Orthosiphon glabratus, *Benth.*
Gelonium lanceolatum, *Willd.*
Curculigo orchioides, *Gaertn.*
Aneilema giganteum, *R. Br.*

In vol. i. of the Herbarium, fol. 18, is a specimen, not numbered, labelled by Linnæus "*Günthera.*" The plant is *Turræa villosa*, Benn., which is a native of some of the hills of Southern India, but never recorded for Ceylon. This specimen is not mentioned in the 'Musæum Zeylan.' p. 4, nor taken up in the 'Flora Zeylanica.' Linnæus's *Günthera* was never published; but there is a MS. full description of it by Linnæus at the end of his own copy of the 'Flora Zeylanica' in the Society's possession.

On Bigeneric Orchid Hybrids. By ROBERT ALLEN ROLFE, A.L.S., Assistant in the Herbarium of the Royal Gardens, Kew.

[Read 5th May, 1887.]

(PLATE IV.)

Zygocolax × *Veitchii*, Rolfe*, is a remarkable bigeneric hybrid which recently flowered in the Royal Exotic Nursery of Messrs. James Veitch and Sons at Chelsea. It was raised by Mr. Seden, the well-known hybridist, by crossing *Zygopetalum crinitum*, Lodd., with the pollen of *Colax jugosus*, Lindl., the seed having been sown in April 1882. The two parents are somewhat diverse in structure, as the accompanying Plate IV. will show. In Bentham and Hooker's 'Genera Plantarum,' however, *Colax* is reduced as a synonym of *Lycaste*, a course which hardly seems warranted by the structure of the two; so that for the purpose of the present paper I have treated *Colax* as a distinct genus.

The diversity in structure between this genus and *Zygopetalum* renders the occurrence of a hybrid between them a matter of considerable interest, especially as hybrids generally are known to be more or less intermediate between the two parents. This case is no exception to the general rule, as the accompanying Plate will show. The flower, in shape, is tolerably intermediate between the two parents, the coloration most closely resembling that of the seed-parent, and the pollinarium approaching rather that of the pollen-parent.

Being so far intermediate between the two parents, the question arose as to how the plant should be treated in the scheme of classification. Several bigeneric hybrids of Orchidaceæ have been artificially produced; and looking for the precedents adopted in these cases, I found the information respecting them to be very vague, and the nomenclature generally unsatisfactory. So that instead of confining my remarks to *Zygocolax*, I have extended the paper so as to include other bigeneric hybrids of the Order, and have specially considered the subject in its general bearing upon classification.

The way in which bigeneric hybrids of Orchidaceæ have hitherto been treated (omitting specific details) may be briefly summarized as follows, the seed-parent being enumerated in the left-hand column, the pollen-parent in the middle, and the hybrid (or result) in the right-hand one:—

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* Gard. Chron. 1887, pt. 1, p. 765.

Seed-parent.	*Pollen-parent.*	*Hybrid.*
Phaius.	Calanthe.	Phaius.
Anœctochilus.	Goodyera *.	Anœctochilus.
Goodyera*.	Anœctochilus.	Goodyera.
Cattleya.	Lælia.	Cattleya (in one case).
Cattleya.	Lælia.	Lælia (in four cases).
Lælia.	Cattleya.	Lælia.
Cattleya.	Sophronitis.	Lælia.

The result obtained from a study of the above Table is somewhat curious. If *Phaius* be crossed with *Calanthe*, a *Phaius* is the result; though we have no example of what would happen were the cross effected the reverse way. The next two cases, however, supply this deficiency, as *Goodyera* and *Anœctochilus* may be crossed either way, the result depending entirely on which way the cross is effected.

Thus far the influence has been on the side of the seed-parent, a result with which *Lælia* crossed with *Cattleya* also agrees. But when the cross is effected the reverse way, *Lælia* becoming the pollen-parent, the result is in one instance a *Cattleya*, but in no less than four others a *Lælia*. So that the influence is now transferred to the side of the pollen-parent. But in the last case the result is yet more remarkable. If *Cattleya* be crossed with *Sophronitis*, the hybrid product belongs to neither of the parent genera, but to yet a third, namely, *Lælia*.

One case included in the above deserves a closer examination. *Cattleya Mossiæ* (a form of *C. labiata*) crossed with *Lælia purpurata* is reported to have produced at one time *Cattleya exoniensis* ×, Reichb. f., and at another *Lælia Canhamiana* ×, Reichb. f. It is only fair, however, to add that in the former case the parentage was not so carefully recorded as in the latter, leaving perhaps a slight possibility of some mistake †.

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* The plant in question is the old *Goodyera discolor*, Ker, now *Hæmaria discolor*, Lindl., and not a true *Goodyera*. But it generally goes under the old name in gardens; and for the purpose of this Table it is convenient to retain the name under which the hybrids were described. Later in this paper it is mentioned under its true name.

† I have it on the authority of the Messrs. Veitch that the pedigree of some of their early hybrids was not so carefully recorded as it has been in more recent years.

The value of such a system is at once apparent. To take the case of *Phaius grandifolius*, Lour., crossed with the pollen of *Calanthe vestita*, Wall. These two genera are placed by Bentham in distinct subtribes, and at least are sufficiently distinct, whether the subtribal difference be maintained or not. But when the hybrid flowered, it was described by Prof. Reichenbach[*] as *Phaius irroratus* × ; and this author then reduced *Calanthe vestita*, Wall., to *Phaius vestitus*, Reichb. f.; thus removing the plant from its immediate allies, and placing it in a position for which there is no justification. On the same grounds, the distinction between *Cattleya* and *Lælia* has been held to be merely an artificial one, and *Sophronitis* abandoned, except for a single species, which does not materially differ from the remaining ones, and should stand or fall with them. If the future naming of bigeneric hybrids is to be conducted on these principles, there is no telling where we shall ultimately be landed, as the list is likely to be considerably augmented in the future.

On the other hand, we have the course adopted by Dr. Maxwell T. Masters in the case of *Philageria* ×, a hybrid produced by crossing *Lapageria rosea*, Ruiz and Pav., with the pollen of *Philesia buxifolia*, Lam. This name was compounded from that of the two parents, the plant being called *Philageria* × *Veitchii*, Mast.[†] Such a course seems perfectly legitimate, and one which forms a precedent that may safely be followed in other similar cases.

Before, however, examining these hybrids in detail, it will be as well to consider them in their general bearing upon classification. The question was propounded by Mr. Harry J. Veitch in his paper on "The Hybridization of Orchids"[‡] read before the Orchid Conference, "How will these bigeneric crosses affect the stability of the genera as at present circumscribed? And what changes of nomenclature will be necessary to place the Orchideæ on an intelligible basis as regards names?"

To answer these queries aright both the positive and negative results of hybridization must be considered. As to positive results, besides the hybrids afore-named there is one other, at least, in existence, but which has not yet flowered, namely—

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[*] Gard. Chron. 1867, p. 264, with fig.

[†] Ibid. 1872, p. 358, figs. 119, 120.

[‡] Ibid. 1885, i. pp. 628–632, with numerous figures; also Journ. Hort. Soc. vii. pp. 22–36, with five Plates.

Selenipedium crossed with *Cypripedium.*

And of other crosses which have been effected, and capsules produced, but from which no seedlings have been raised, we have

Bletia crossed with *Calanthe.*
Acanthephippium crossed with *Chysis.*
Chysis ,, ,, *Zygopetalum.*
Zygopetalum ,, ,, *Lycaste.*
Odontoglossum ,, ,, *Zygopetalum.*

Negative results are more difficult to deal with, as several failures may in some instances be followed by success. Still, from the long experience of the Messrs. Veitch in this field, the following extracts from the afore-named paper of Mr. Harry Veitch may be admitted as fairly proven facts. Speaking of *Masdevallia* he says:—

"*Masdevallia*, as a genus, is far more heterogeneous than was at first supposed, whence a mixture of the different sections may not possibly be effected. . . . All attempts to intermix *M. Chimæra* and its allies with the brilliant-flowered species have proved fruitless."—*Veitch, Journ. Hort. Soc.* vii. p. 33.

Respecting *Cattleya* and *Lælia*, we find the following:—

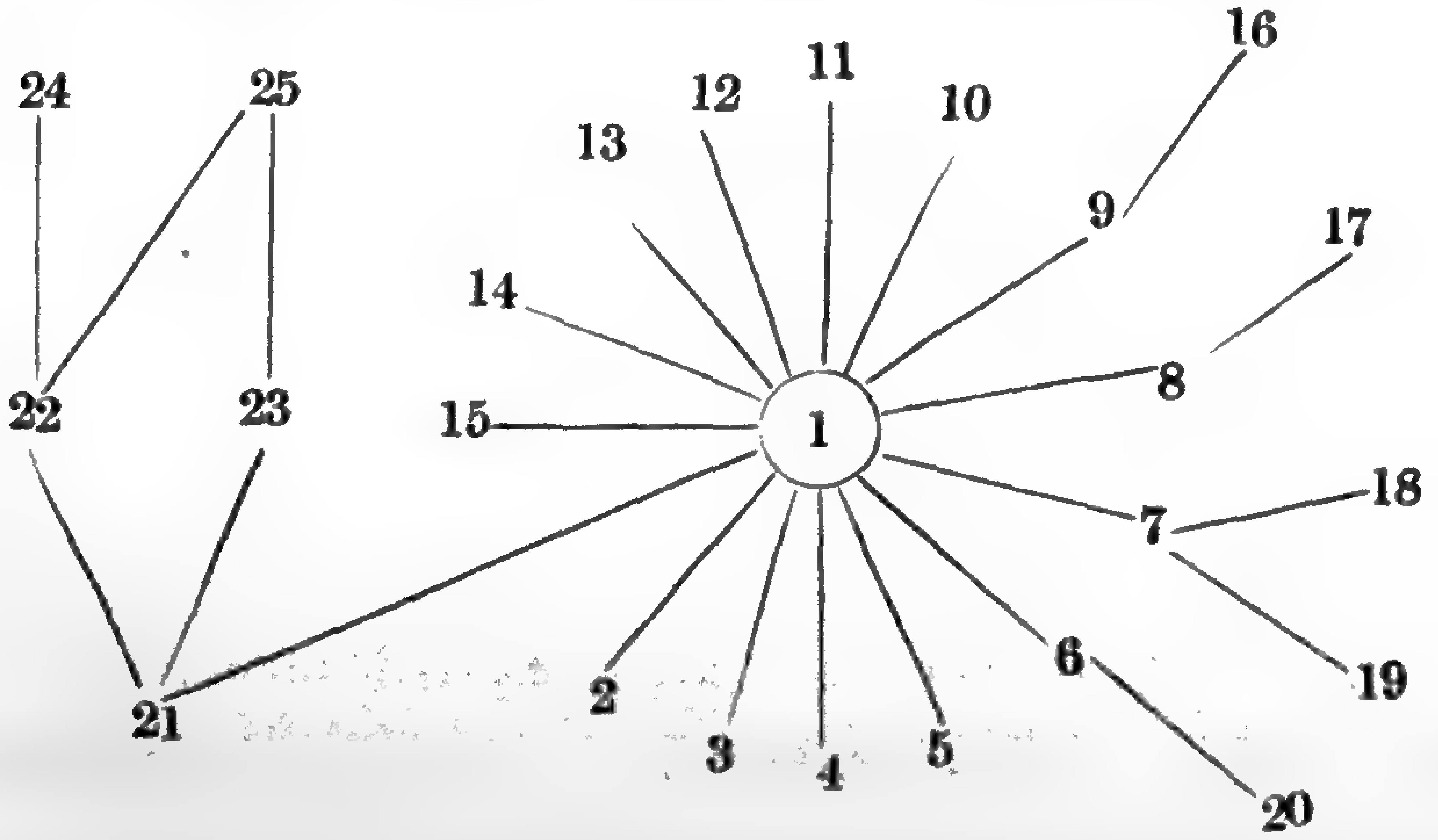
" Among *Cattleyas* we find that all the members of the *labiata* group and also the Brazilian species with two-leaved stems, as *C. intermedia*, *C. Aclandiæ*, *C. superba*, &c., cross freely with each other and with the Brazilian *Lælias*, which also cross freely with each other. . . . But neither the *Cattleyas* nor the Brazilian *Lælias* will cross freely with the Mexican *Lælia albida, autumnalis, majalis, rubescens*, &c. Numerous crosses have been effected both ways, and capsules have been produced, but the seed has always proved barren. *L. anceps* appears to be an exception; for it seeds freely, whether crossed with a *Cattleya* or with any of the Brazilian *Lælias*."—*Veitch*, *l. c.* p. 29.

Coming to *Cypripedium*, the genus which of all others has most readily lent itself to the arts of the hybridizer, we find that while seedlings have been raised from the Tropical American *Selenipedium caudatum* crossed with the Indian *Cypripedium barbatum*, yet attempts to cross the Indian species with the North-American *C. spectabile* have not been attended with much success. The cross has been attempted several times, and Mr. Seden has obtained swollen seed-pods, but their contents have invariably turned out to be nothing but chaff; at least, he has never succeeded in inducing any seed to germinate. And there are many other instances within the limits of the Order where species of the same genus, and in some cases closely allied species, have hitherto successfully resisted all the arts of the hybridizer to effect a cross between them.

So that, without insisting too strongly on the value of every item of negative evidence adduced, we are still justified in assuming that while in some instances hybridization may be effected between species belonging to diverse genera, yet in other cases it may not be effected even between species belonging to the same genus.

The question here naturally arises, Are these genera which may be hybridized together really distinct? A negative answer is sometimes given to this query, though an affirmative one is more in harmony with the gradually accumulating evidence on the subject. To deny the distinctness of genera between which hybridization can be (artificially) effected differs only in degree from what was once maintained with respect to species, namely that so-called species which would hybridize together were not really distinct, but only forms of the same species. But this theory is now completely exploded; and it seems to me that, with respect to genera, the idea will also have to be given up, as the analogy between the two cases is so very close. This analogy may be readily expressed in diagrammatic form as follows:—

TABLE I., showing how *Cypripedium barbatum* has been connected with other species by artificial hybridization.



List of Species, the numbers agreeing with those in the foregoing Diagram.

1. Cypripedium barbatum.
2. —— philippinense.
3. —— Stonei.
4. —— Lowei.
5. —— Fairrieanum.
6. —— superbiens.
7. —— villosum.
8. —— insigne.
9. —— Lawrenceanum.
10. —— Hookeræ.
11. —— Dayanum.
12. —— hirsutissimum.
13. —— venustum.
14. Cypripedium concolor.
15. —— niveum.
16. —— purpuratum.
17. —— Spicerianum.
18. —— Druryi.
19. —— Argus.
20. —— javanicum.
21. Selenipedium caudatum.
22. —— Pearcei.
23. —— longifolium (Roezlii).
24. —— caricinum.
25. —— Schlimii.

The above table shows that *Cypripedium barbatum* has been crossed with one species of *Selenipedium* and with fourteen species of *Cypripedium*. Of these fourteen species five have also been crossed with five other species, while the species of *Selenipedium* has been crossed with two other species of that genus, and these again with yet two additional ones. That is, twenty species of *Cypripedium* and five species of *Selenipedium* have been connected by artificial hybridization; and these again have been connected by *Selenipedium caudatum* crossed with *Cypripedium barbatum*; so that all these twenty-five species, of two genera, may be said to be linked together by the skill of the hybridist. The diagram is not arranged to show the various combinations which have been effected between these species, which details can be better expressed as in Table II. (See p. 162.)

From this table we see that thirty-three combinations have been effected between the twenty species of *Cypripedium*, and five combinations between the five species of *Selenipedium*; while the two groups have been connected by the hybrid raised from *Selenipedium caudatum* crossed with *Cypripedium barbatum**, or thirty-nine hybrids altogether. All these hybrids, with the exception of the last-named†, have flowered, received distinctive names, and are now in cultivation in various horticultural establishments.

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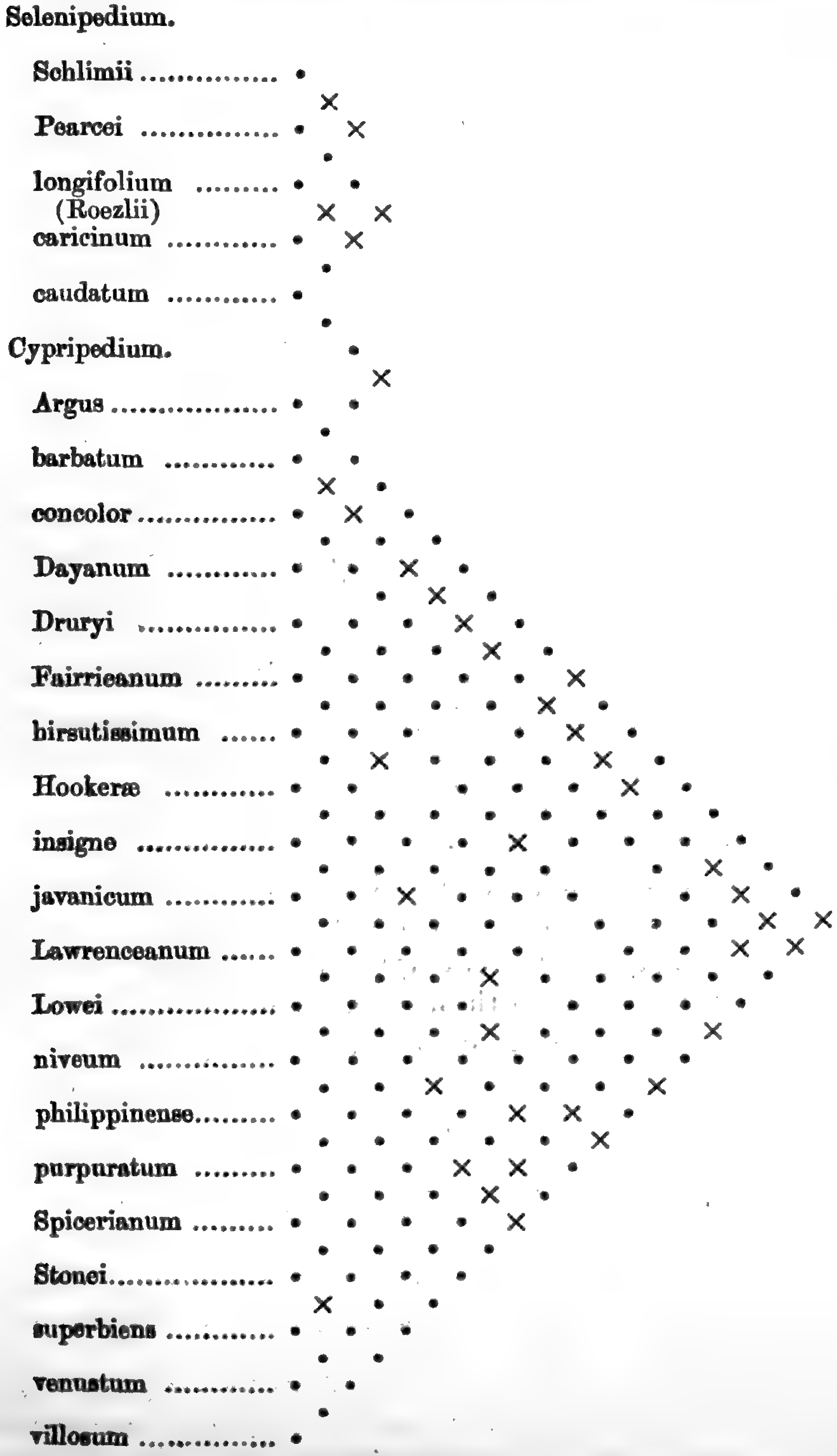
* "One thing is certain, the three-celled ovary of the Selenipeds offers no impediment to fertilization by the pollinia of Cypripeds with a one-celled ovary, for we have plants raised from *C. caudatum* [*Selenipedium*] × *C. barbatum*, and many other like crosses have yielded seed."—*Veitch, Journ. Hort. Soc.* n. s. vii. p. 30.

† This hybrid is in many respects a remarkable one. It was raised about 1872; and although the plants continue strong and healthy in appearance, and increase in size every year, yet up to the present time not a single plant has flowered.

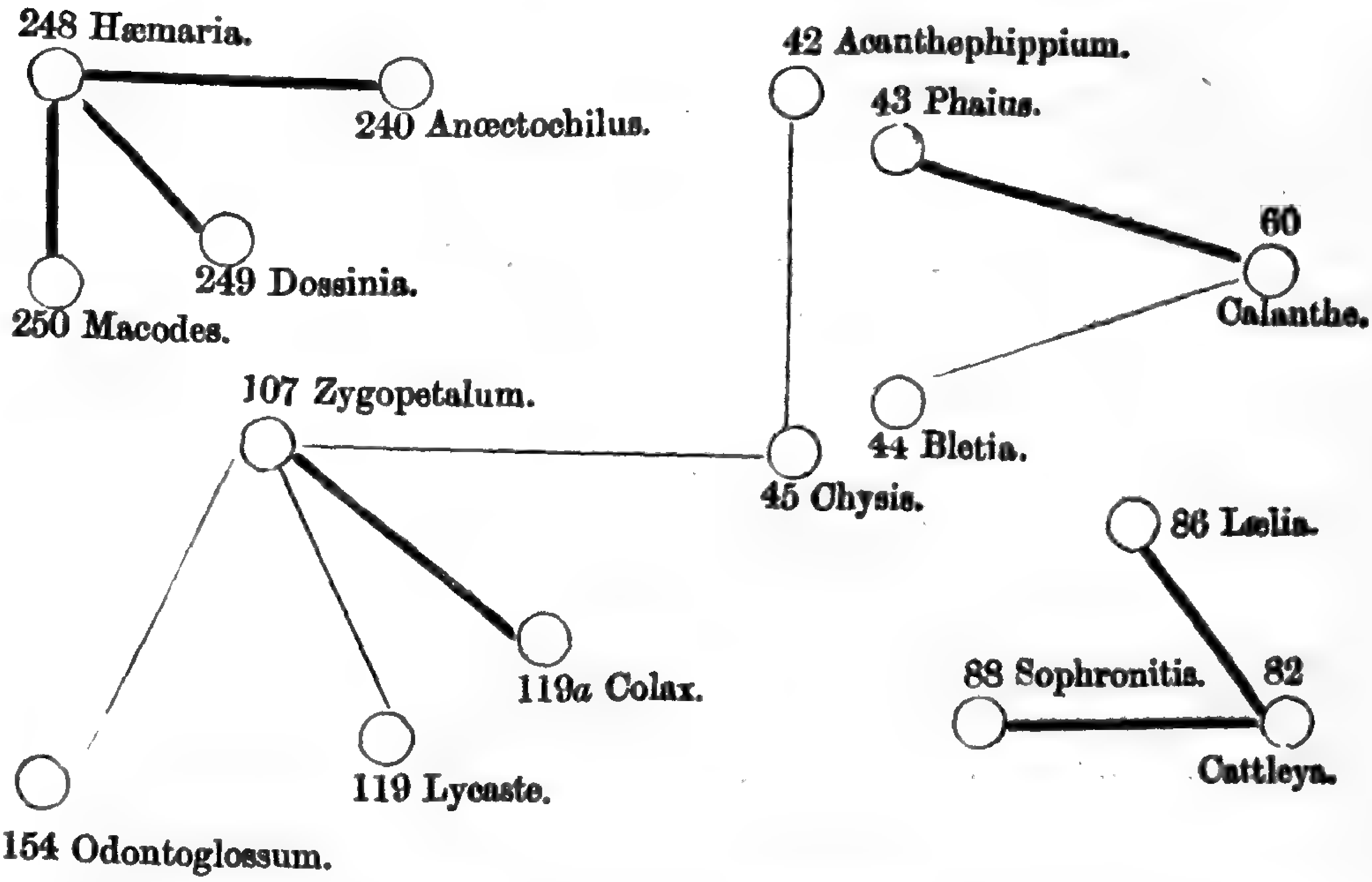
TABLE II., showing the combinations which have been effected between the twenty-one species given in Table I.


Selenipedium.
Schlimii
Pearcei
longifolium (Roezlii)
caricinum
caudatum
Cypripedium.
Argus
barbatum
concolor
Dayanum
Druryi
Fairrieanum
hirsutissimum
Hookeræ
insigne
javanicum
Lawrenceanum
Lowei
niveum
philippinense
purpuratum
Spicerianum
Stonei
superbiens
venustum
villosum

These results are indeed remarkable, if not unsurpassed in the whole history of artificial hybridization. They indeed suggest the possibility of the whole of the tropical species of these two genera being ultimately connected in this manner.

We have now the question of hybridism between distinct genera to consider, and, as before, the results obtained can best be expressed in diagrammatic form.

Table III., showing the connections which have been obtained between distinct genera by artificial hybridization.


248 Hæmaria.
240 Anœctochilus.
249 Dossinia.
250 Macodes.
42 Acanthephippium.
43 Phaius.
60 Calanthe.
44 Bletia.
45 Chysis.
107 Zygopetalum.
119a Colax.
119 Lycaste.
154 Odontoglossum.
86 Lælia.
88 Sophronitis.
82 Cattleya.

Four distinct diagrams are here represented, and with no connection between them, though it is convenient to place them side by side. The thick lines represent bigeneric hybrids which have flowered and been described; the thin ones represent crosses which have been effected and capsules produced, but from which no seedlings were raised*. The numbers preceding the names are taken from Bentham and Hooker's 'Genera Plantarum,' and are given to show the relative positions of the genera in the system of classification there adopted.

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* "When we enumerate the capsules which have been obtained from bigeneric crosses, but from which no seedlings have been raised, the list is somewhat more formidable. Some of the most remarkable of these were produced by *Acanthephippium Curtisii* × *Chysis bractescens*, *Bletia hyacinthina* × *Calanthe masuca*, *Chysis aurea* × *Zygopetalum Sedeni* [itself a hybrid.—R. A. R.], *Odontoglossum bictoniense* × *Zygopetalum maxillare*, and *Zygopetalum Mackayi* × *Lycaste Skinneri*. But, on the other hand, we have obtained a large number of capsules of the normal size, and to all appearance externally perfect, not only from bigeneric crosses, but even between species of the same genus, which contained not a single seed. And, lastly, I may note that *Zygopetalum Mackayi* has been crossed with several species of *Odontoglossum*, and seedlings raised from some of the crosses; but every one that has yet flowered has proved to be *Zygopetalum Mackayi*."—*Veitch, Journ. Hort. Soc.* n. s. vii. p. 35.

The above diagram is extremely instructive, and fully bears out the analogy pointed out between this and the preceding case. We may consider existing hybrids first.

The four genera *Anœctochilus*, *Hæmaria*, *Dossinia*, and *Macodes* belong to the tribe *Neottieæ*; and, though closely allied, they possess certain structural differences which have been used for generic distinction. An interesting point in connection with this group is that *Hæmaria* has been crossed with each of the other three genera, *Hæmaria discolor*, Lindl., being in each case one of the parents. In two of the cases it was the seed-parent; and although particulars are not fully given in the third case, still I strongly suspect in this also it was the seed-parent.

The three genera *Cattleya*, *Lælia*, and *Sophronitis* belong to Bentham's subtribe *Læliæ*, and are confessedly closely allied; but the structural differences are such as to preclude the idea of uniting them together. The former has four pollen-masses, the two latter have eight; and to give up the characters derived from the number of pollen-masses would be to disown one of the characters universally relied on for generic distinction. So important, indeed, has the character been considered, that Prof. Reichenbach, in the sixth volume of Walpers's 'Annales,' reduced *Cattleya* and two other genera to *Epidendrum*, and *Lælia* and four others to *Bletia*, on these very grounds, yet left *Sophronitis* as distinct. Lately, in a recent issue of that splendidly illustrated work, 'Sander's Reichenbachia,' he again inculcates the same views*.

On the other hand, so many hybrids have been raised between *Cattleya* and *Lælia*, that Mr. Veitch, in the afore-mentioned papers, relying on this very fact and on the difficulty of saying to which of the two genera some of these hybrids should be referred (and they have always been referred to one or the other, sometimes very arbitrarily), remarked that the distinction between *Cattleya* and *Lælia* "was confessedly an artificial one." If we try to harmonize these two views, we are reduced to the necessity of merging the whole range of genera from *Epidendrum* to *Bletia* into one.

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* "I have never endeavoured to thrust upon amateurs such undoubtedly necessary changes as the merging of the genus *Cattleya* into *Epidendrum*, or *Lælia* and *Schomburgkia* into the genus *Bletia*."—*Reichb. f. in Sander's Reichenbachia*, sub t. 25.

Colax and *Zygopetalum* (the former reduced by Bentham to *Lycaste*, but here restored) belong to the subtribe *Cyrtopodieæ*; but as considerable differences exist in the structure of the pollinarium, they are placed twelve genera apart. In fact, Bentham makes two groups, one with an elongated stipes on which the pollen-masses are seated, the other having them sessile on the gland; *Colax* is placed in the former group, and *Zygopetalum* in the latter. So here, again, structural differences preclude the idea of merging the two genera in one. And if this were done, new characters must be sought for subdividing the *Cyrtopodieæ*, or the nineteen genera be reduced to very few.

The case of *Phaius* and *Calanthe* is yet more remarkable, as they are placed in distinct subtribes by Bentham—*Phaius* in *Bletideæ*, and *Calanthe* in *Cœlogyneæ*. So that in this case, to unite the two genera would be to unite the two subtribes in one; and how many genera would follow suit it is difficult to say—that is, assuming Bentham's views as to the gap which separates these two genera to be substantially correct. Structurally different they certainly are; and in this, as in the preceding cases, the differences are such as have hitherto been relied on as sufficient for generic distinction. If these structural differences are to be ignored because the plants possessing them can be hybridized together, the whole system of classification will be thrown into confusion. Indeed it would be kept in a state of perpetual ferment, as the advent of every new bigeneric hybrid would furnish the opportunity of overhauling existing arrangements in order to bring them into harmony with new discoveries.

It may be that some of these are already foreshadowed by the connections represented by the thin lines on the above diagram—crosses effected and capsules produced, but no seedlings raised. Future experiments in this direction may be attended with greater success, as has already been the case in several other instances. At present these cases can only be considered as indicating future possibilities; yet as capsules were produced, the fertilizing influence of the pollen cannot be doubted. These are not cases where, as Darwin puts it, the pollen had no more effect, when applied to the stigma, than so much inorganic dust. Passing them briefly in review, we may first take *Acanthephip-*

pium crossed with *Chysis*. These two genera are very closely allied, the two genera placed between them by Bentham being *Phaius* and *Calanthe*. *Zygopetalum* crossed with *Lycaste* furnishes an almost parallel case to the same genus crossed with *Colax*; and therefore calls for no special comment. *Bletia* crossed with *Calanthe* is almost analogous with *Phaius* crossed with *Calanthe*, as *Bletia* and *Phaius* stand together in *Bletideæ*, while *Calanthe* is placed in *Cœlogyneæ*. *Odontoglossum* crossed with *Zygopetalum* is an interesting connection, the former being placed in *Oncidieæ*, the latter in *Cyrtopodieæ*. The same genera, crossed the reverse way, are mentioned in a footnote on p. 163. In that case the result of the cross was always simply *Z. Mackayi* (the mother plant), a fact somewhat difficult to account for. But the last connection is a very remarkable one, namely, *Chysis* crossed with *Zygopetalum*. *Chysis* belongs to the tribe *Epidendreæ*, *Zygopetalum* to *Vandeæ*. As to these primary divisions of the Order, no difference of opinion exists between botanists; and the pollinaria are so different in the two cases, that the results of future experiments in this direction, either as confirming or disproving the possibility of hybridization between such diverse genera, will be awaited with great interest.

We therefore see that the results of hybridization in this Order have been of a remarkable and somewhat unlooked-for nature—results which may or may not have a very important bearing upon classification, according to the light in which they are considered. Hitherto, as we have already seen, bigeneric hybrids have either been placed in one of the parent genera, or some rearrangement has been proposed in order to harmonize with the supposed new discoveries. If this course is to be persisted in, no finality can ever be anticipated while these hybridizing experiments continue. *Calanthe Dominii*, raised between *C. masuca* and *C. furcata*, was the first artificial hybrid Orchid which flowered. When, in October 1856, it was shown to Dr. Lindley, he remarked to the late Mr. Veitch, "Why! you will drive the botanists mad." And if our ideas of classification must be taken from the hybridist, there is much truth in the remark. I do not, however, think such a course is either desirable or necessary. These hybrids are mostly artificial productions; and, for various reasons, very few of them may be expected to occur in a state of nature. Over a hundred have been raised in gardens in this country; and of these only two are known in a wild state. *Phalænopsis inter-*

media, described many years ago, has recently been raised by the Messrs. Veitch, by crossing *P. Aphrodite* with *P. rosea*; and *Cypripedium Morganiæ*, raised between *C. Stonei* and *C. superbiens*, is so substantially similar to the wild *C. Stonei*, var. *platytænium*, that the latter is now supposed to be a natural hybrid between these two species.

From the foregoing details we may make the following deductions; and these again indicate a method of treating these hybrids which seem to me at once unobjectionable in itself, and does not interfere with the existing classification of genera and species:—

1. Hybridization may take place not only between distinct species, but also between distinct genera—or between plants so structurally different as to be usually regarded as such.

2. These hybrids are generally of artificial origin, or accidentally produced, and cannot be treated in the scheme of classification either as varieties, species, or genera.

3. The possibility of hybridization taking place between species hitherto considered as distinct does not necessarily prove them to be merely forms of the same species.

4. The occurrence of a hybrid between two structurally different genera does not prove the necessity of uniting them in one; nor can such hybrids be arbitrarily referred to either of the parent genera.

5. Species, and genera too, will always have to be dealt with in the scheme of classification according to their structural peculiarities and differences, without reference to the possibility of hybridization taking place between them.

It is therefore clear that hybrids, whether bigeneric or otherwise, should be dealt with on their own merits, and named in such a way as to avoid all confusion between them and existing species and genera. In the case of species the common practice has been to give to a hybrid a new specific name, followed by a "×" to indicate the hybrid origin of the plant. Thus *Cypripedium Harrisianum* × is a hybrid raised from *C. villosum* crossed with *C. barbatum*; though, to my mind, a name indicating at once its hybrid origin and parentage, as *C. barbato-villosum*, would have been preferable. It the case of bigeneric hybrids it seems to me that the plan of compounding a name from that of the two parents should always be followed, as "*Philageria* ×," a name invented by Dr. Masters for a hybrid raised by crossing *Lapa-*

geria rosea with the pollen of *Philesia buxifolia.* By this means all confusion between them and natural genera would be avoided.

The rest of this paper is devoted to carrying this idea into practice for the bigeneric hybrids already in existence.

PHAIOCALANTHE ×.—This name is proposed for the hybrids produced between *Phaius* and *Calanthe*—two very distinct genera, and placed by Bentham in distinct subtribes. The former genus has been the seed-parent in the crosses at present effected; and on the principle of placing the name of the pollen-parent first, some would have used the names the reverse way. But this does not seem to me a matter of vital importance, as in two of the following cases crosses have been effected both ways. The essential point seems to be to compound some euphonious name from that of the two parent genera, which shall serve as a sort of artificial genus for all the hybrids produced between those genera. Were the rule of placing the name of the pollen-plant first to be always adopted in compounding new names for bigeneric hybrids, it would, in the case of *Cattleya* and *Lælia* (and in other cases), lead to two names being used for practically the same thing, a course which seems both undesirable and unnecessary.

P. × IRRORATA.—Phaius irroratus, *Reichb. f. in Gard. Chron.* 1867, p. 264, with fig.; also 1882, pt. 2, p. 565, fig. 100; *Fl. Mag.* t. 426.—A hybrid produced between *Calanthe vestita*, Wall., ♂, and *Phaius grandiflorus*, Lour., ♀, and partaking of the characters of both parents. The cross was effected a second time; and as the progeny in this case proved somewhat darker in colour, it was called var. *purpureus*. For the present purpose, however, these colour-varieties need not be taken account of, as variation in this respect in the hybrid offspring is readily induced by selecting different colour-varieties in the parents*.

LÆLIOCATTLEYA ×.—Proposed for the hybrids between *Lælia* and *Cattleya*, the species of which readily hybridize together. The species of these genera have eight or four pollen-masses respectively; but the hybrids between them are so irregular in this respect, that the greatest confusion exists between the two genera. By separating these hybrids as proposed, the boundaries of the two genera will be clearly defined.

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* *Phaius inquilinus*, Reichb. f. in Gard. Chron. 1867, p. 544, might appear to come under *Phaiocalanthe* ×, as its parents are said to be, probably (the record being lost), *Phaius vestitus* and *Calanthe masuca* or *C. versicolor*. *Phaius vestitus* (Reichb. f. in Gard. Chron. 1867, p. 264, in note under *P. irroratus*), however, is simply *Calanthe vestita*, Wall., a genuine *Calanthe*, which never ought to have been called *Phaius* at all. So that *P. inquilinus* is not a bigeneric hybrid, but a true *Calanthe*, which may stand as *C. inquilina* ×.

L. × AMESIANA.—Lælia Amesiana ×, *Reichb. f. in Gard. Chron.* 1884, pt. 1, p. 109.—A hybrid raised between *Cattleya maxima*, Lindl., ♂, and *Lælia crispa*, Reichb. f., ♀.

L. × BELLA.—Lælia bella ×, *Reichb. f. in Gard. Chron.* 1884, pt. 1, p. 174.—A hybrid raised between *Cattleya labiata*, Lindl., ♂, and *Lælia purpurata*, Lindl., ♀.

L. × CALLISTOGLOSSA.—Lælia callistoglossa ×, *Reichb. f. in Gard. Chron.* 1882, pt. 1, p. 76.—A hybrid raised between *Cattleya Warsczewiczii*, Reichb. f. (one of the multitudinous forms of *C. labiata*, Lindl.), ♂, and *Lælia purpurata*, Lindl., ♀.

L. × CANHAMIANA.—Lælia Canhamiana ×, *Reichb. f. in Gard. Chron.* 1885, pt. 2, p. 6.—A hybrid raised between *Lælia purpurata*, Lindl., ♂, and *Cattleya Mossiæ*, Lindl. (a form of *C. labiata*, Lindl.), ♀.

L. × EXONIENSIS.—Cattleya exoniensis ×, *Reichb. f. in Gard. Chron.* 1867, p. 1144; *Jennings, Orch.* t. 1.—Said to have the same parentage as the preceding, but the plant is so different that some mistake has probably been made.

L. × FELIX.—Cattleya felix ×, *Reichb. f. in Gard. Chron.* 1876, pt. 2, p. 68.—A hybrid raised between *Cattleya Schilleriana*, Reichb. f., ♂, and *Lælia crispa*, Reichb. f., ♀.

L. × MYLAMIANA.—Lælia Mylamiana ×, *Reichb. f. in Gard. Chron.* 1876, pt. 2, p. 740, fig. 138.—A hybrid raised between *Lælia crispa*, Reichb. f., ♂, and *Cattleya granulosa*, Lindl., ♀.

L. × PHILBRICKIANA.—Lælia Philbrickiana ×, *Reichb. f. in Gard. Chron.* 1879, pt. 2, p. 102.—A hybrid raised between *Lælia elegans*, Reichb. f., ♂, and *Cattleya Acklandiæ*, Lindl., ♀.

L. × VEITCHIANA.—Lælia Veitchiana ×, *Reichb. f. in Gard. Chron.* 1874, pt. 1, p. 566; *Fl. Mag.* n. s. t. 305.—A hybrid raised between *Cattleya labiata*, Lindl., ♂, and *Lælia crispa*, Reichb. f., ♀.

SOPHROCATTLEYA ×.—Proposed for a hybrid raised between *Cattleya* and *Sophronitis*, a genus closely allied to *Lælia*.

S. × BATEMANNIANA.—Lælia Batemanniana ×, *Reichb. f. in Gard. Chron.* 1886, pt. 2, p. 263.—A hybrid raised between *Sophronitis grandiflora*, Lindl., ♂, and *Cattleya intermedia*, Grah., ♀.

ZYGOCOLAX ×, *Rolfe in Gard. Chron.* 1887, pt. 1, p. 765.—Proposed for a hybrid raised between *Colax* and *Zygopetalum.* The former genus is reduced by Bentham to *Lycaste,* though its structural peculiarities, particularly the absence of a distinct gland, seem sufficient to warrant its retention. (See Plate IV.)

Z. × VEITCHII, *Rolfe in Gard. Chron.* 1887, pt. 1, p. 765.—A hybrid raised between *Colax jugosus,* Lindl., ♂, and *Zygopetalum crinitum,* Lodd., ♀.

ANŒCTOMARIA ×.—Proposed for a hybrid between *Anœctochilus* and *Hæmaria.*

A. × DOMINII.—Anœctochilus Dominii, cf. *Proc. Roy. Hort. Soc.* v. (1865) p. 139.—A hybrid raised between *Hæmaria discolor,* Lindl., ♂, and *Anœctochilus Lobbianus,* Planch., ♀ (*A. xanthophyllus,* hort.), I have not found a full description of this hybrid.

MACOMARIA ×.—Proposed for a hybrid between *Macodes* and *Hæmaria.*

M. × VEITCHII.—Goodyera Veitchii, cf. *Proc. Roy. Hort. Soc.* ii. (1862) p. 546, also v. (1865) p. 139.—A hybrid raised between *Macodes Petola,* Lindl., ♂ (*A. Veitchianus,* hort.), and *Hæmaria discolor,* Lindl., ♀. Like the preceding, this hybrid is but very briefly described.

DOSSINIMARIA ×.—Proposed for a hybrid between *Dossinia* and *Hæmaria.*

D. × DOMINII.—Goodyera Dominii, cf. *Gard. Chron.* 1861, p. 531. —A hybrid raised between *Dossinia marmorata,* Morren (*Anœctochilus Lowii,* Koch et Lauche), and *Hæmaria discolor,* Lindl. It is not mentioned which of these plants was the male and which the female parent; though I strongly suspect the last-named, as in the two preceding cases, was the seed-parent. The description is as brief as possible.

DESCRIPTION OF PLATE IV.

Fig. 1. Flower of *Colax jugosus,* Lindl., nat. size; 1 *a,* its pollinarium (side-front view), ×5 diam. From Bot. Mag. t. 5661.

Fig. 2. Flower of *Zygopetalum crinitum,* Lodd., nat. size. From a drawing in Lindley's Herbarium (lip not in perspective). 2 *a,* its pollinarium (back view), ×6 diam. From nature.

Fig. 3. Flower of *Zygocolax* × *Veitchii,* Rolfe, a hybrid between the foregoing, nat. size; 3 *a,* its pollinarium (back view), ×6 diam. From nature.

Contributions to South-African Botany.—Part III.

By HARRY BOLUS, F.L.S.

[Read 16th June, 1887.]

CRUCIFERÆ.

PALMSTRUCKIA CAPENSIS, *Sond. Flor. Cap.* i. 35 (Peltaria capensis, *Thunb. Flor. Cap.* (ed. 1823) p. 490).—This species has hitherto been known only from a deflorate specimen collected by Thunberg about the year 1774, and existing in his herbarium now preserved at Upsala. No collector appears to have met with it since that date, until in 1883 I was fortunate enough to find what is doubtless the same species both in flower and fruit. I am indebted to the authorities of the Royal Herbarium at Kew for most valuable assistance (in this as in so many other instances) in comparing my specimens with Thunberg's type, kindly lent by Prof. Berggren for the purpose; and I think it will be useful to students of South-African plants to record the results, more especially as the genus is monotypic and endemic:—Thunberg's specimen consists merely of the upper part of the stem in ripe fruit (the siliquæ being ½ in. in diameter, while those of my specimens are not quite mature), and with but three or four leaves upon it. These are all bract-leaves at the base of the racemes, and there are no lower ones. They are linear-filiform and undivided with the exception of one, which shows a small tooth on one side and an appearance of an opposite one, which (owing to the state of the specimen) cannot be distinctly seen. So far as the specimen goes, it agrees with my plants; and it is probable that the lower leaves had fallen as maturity approached, and that Thunberg described the leaves from the specimen before him as filiform. His specimen was collected in the month of November, mine in September. I append a description of the latter:—

Herbacea, erecta, sparse et minute hispida, 20–40 centim. alta; caulis erectus, dichotome ramosus; folia pinnatipartita, jugis 1–3 distantibus, lobis linearibus, folia infima 6 cm. longa, superiora sensim minora, suprema vix divisa; racemi laxi, fructiferi 10–15 cm. longi, pedicellis gracilibus patentibus apice pendulis, 1·5 cm. longis; sepala elliptica, obtusa, concava, margine membranacea, 1 millim. longa; petala obovata, 2·5 millim. longa; stamina lateralia basi appendiculata; stylus brevis, interdum

brevissimus, stigmate majusculo subsessili; ovarium ellipticum; siliqua orbicularis, 1 cm. [in exempl. Thunbergiano 1·5 cm.] diametro. (*v. v.*; *descr. ex exempll. plur. exsicc. sub num.* 6502 *distributis.*)

Hab. In lapidosis, Kasteel Poort prope Klipfontein, in montibus Kaus, ditione Namaqualand Minor, alt. circ. 900 metr., mense Sept., anno 1883, legi. No. 6502 in herbb. meo, Kewensi, &c.

Kasteel Poort is about 56 miles from Port Nolloth by the Copper Mining Company's tramway, and I found the plant growing copiously in a patch near the western entrance to the Poort, the season being an extraordinarily good one. I confess I took it for some *Heliophila*, little thinking it was the rare *Palmstruckia*, and hence only gathered about eight specimens. Namaqualand is a very dry and a not easily accessible country; annuals such as this only spring up after suitable rains, and I have not been able as yet to get any one to gather it again.

MALVACEÆ.

HIBISCUS MICRANTHUS, *Linn.*—This occurs amongst Burchell's plants No. 2264, Litaakun, Sept. 1812; and 2364, Maadji Mountain, Oct. 1812. The South-African locality has not yet been published.

STERCULIACEÆ.

MELHANIA GRIQUENSIS, *Bolus*, n. sp. Decumbens, ramis adscendentibus, 35–40 centim. longis. Stipulæ filiformes. Folia oblongo-elliptica oblonga, vel (in exempll. Orpenianis) lineari-oblonga, basi cuneata, grosse serrata, 3–4 cm. longa, 1–1·5 cm. lata, cano-pubescentia demum subglabrescentia, petiolis 0·7–1·3 cm. longis; pedunculi axillares, sæpius biflori, demum reflexi, 7–8 millim. longi; pedicelli 2–4 mm. longi; epicalycis segmenta lineari-subulata, sepalis breviora; sepala lanceolata acuminata, 8 mm. longa, capsulam oblongam stellato-tomentosam æquantia; semina lævia. (*Ex exempll. exsicc. Burchellianis*, No. 2050).

Hab. Kloof Village, Asbestos Mountains (Griqualand West), Feb. 1812; *Burchell*! No. 2050!; Griquatown, *Mrs. Orpen*; Herb. Bolus No. 6045. [Also, rocks at the Chue Spring, Oct. 7, 1812, *Burchell* 2385; Bakwena Territory, Betchuana Country, *Dr. Holub*; and Klippan, Boshveld, Transvaal, *Rehmann* 5220 in herb. Kew.—*N. E. Brown.*]

This is nearest to *M. Burchelli*, DC., but differs in its leaves

and some other characters. Mrs. Orpen's plant, from the same locality as Burchell's but gathered sixty years later, agrees in every respect with his specimens, save that the leaves are a little narrower in proportion to their breadth.

TILIACEÆ.

TRIUMFETTA SONDERIANA, *Bolus*.—T. trichocarpa, *Sond. in Linnæa*, xxiii. p. 19.—Under the latter name Hochstetter had already published an Abyssinian species, in *Rich. Fl. Abyss.* i. 84. Sonder's name must therefore be replaced.

CELASTRINEÆ.

CELASTRUS MARITIMUS, *Bolus*, n. sp. Frutex glaber, inermis, ramosus, vel interdum subvirgatus, 2–3-pedalis, ramis cinereis, verrucosis, ramulis angulatis. Folia sæpius elliptica vel ovata, coriacea, acuta, interdum brevissime apiculata, integra, subtus venosa, superne lævia, marginibus reflexis, 2–3 centim. longa, 1·0–1·6 cm. lata, petiolis 2 millim. longis; flores polygami, minimi, in axillas conferti; pedicelli decurvi, 2 mm. longi, bracteis minutis; calycis laciniæ valde inæquales, subrotundæ, concavæ, coloratæ; petala obovato-oblonga, repando-crenulata; stamina brevia; stigma obscure trilobum; ovarium 2-loculare, loculis 2-ovulatis; fructus haud visus. (*Ex exempll. viv. plur.*)

Hab. In arenosis juxta litus maris, sinu Fish Hoek, Peninsulæ Capensis, flor. Aug., legit *Bolus* No. 4767; *Herb. Norm. Austr.-Afr.* No. 307; in coll. arenosis, sinu Plettenberg's Bay, die 14 Aprilis 1814, *Burchell* No. 5320. [Also Somerset, *Bowker*, in herb. Kew.—*N. E. Brown.*]

A well-marked species with rigid leaves and remarkably small clusters of axillary flowers. The petals are a creamy white, and the calyx is nearly the same colour. The venation on the underside of the leaves and the reflexion of the margin are chiefly brought out in drying.

LEGUMINOSÆ.

LOTONONIS FOLIOSA, *Bolus*, n. sp. Tota, petalis exceptis, laxe et longe villosa. Caules (verisimiliter annui) e radice perenne tuberosa plures, erecti, simplices, spithamei, dense foliosi; foliola elliptico-oblonga, acuta, 1·5–1·8 centim. longa, 4–5 millim. lata; stipula solitaria, foliacea, foliolis conformis, subæquilonga, parum angustior; capitula terminalia dense 6–8-flora, pedunculis 4–5 mm. longis, bracteis setaceis, 3 mm. longis; calyx 9 mm. longus, laciniis acuminatis; vexillum obovatum, 1·5 cm. longum; carina

subincurva, obtusa, æquilonga; alæ breviores, basi dentatæ; ovarium subrectum, glabrum, cum stylo (parte inferiore) secus suturam ventralem barbatum. (*Ex exempll. exsicc. plur., MacLea*, No. 5620.)

Hab. In planitiebus, prope Pretoria, Reipublicæ Transvaal, alt. circa 1250 metr., legit *J. H. MacLea*, herb. Bolus, No. 5620. In "Orange Free State," *Cooper*, No. 862; Natal, *Gerrard* 1068. [Also, "In deep rich valley, Limpopo sources," *Nelson*, 268; Olivers Hoek Pass, *Wood* 3542, in herb. Kew.]

This belongs to the section *Lipozygis*, and comes nearest to *L. lanceolata*, Benth., than which it is more hairy, with twice larger flowers &c. I describe from MacLea's specimens. Cooper's are less luxuriant; his ticket describes the flowers as yellow.

[The specimens at Kew, collected by Cooper, MacLea, and Nelson, are 5–6 inches high; those collected by Gerrard are about a foot high.—*N. E. Brown.*]

CROTALARIA GRIQUENSIS, *Bolus*, n. sp. Fruticulus ramosus, rigidus, spinosus, albo-sericeus, 10–20 centim. altus. Rami dichotomi divaricati, spinis tenuibus 1–2 cm. longis; stipulæ subulatæ recurvæ, 1–1·5 millim. longæ; petioli 3-5 millim. longi; folia subpauca, trifoliolata, superne glabra, subtus sericea; foliola obovata, obtusa, interdum emarginata, petiolulata, sæpius complicata, intermedia 8–14 mm. longa, lateralia parum breviora; flores sparsi pauci, 1–2 in spinis racemose penduli; bracteæ minimæ persistentes; pedicelli 2–3 mm. longi; calyx tenuiter sericeus, 4–5 mm. longus, lobis lanceolatis acutis subfalcatis, tubo sublongioribus; corolla fere glabra (vexillum per nervum dorsalem tantum sericeum), aurea, carina pallidiore, calyce 1½–2plo longior; legumen subglobosum, stipitatum, stipite 1·5 mm. longo, venosum, sericeo-pubescens, 5 millim. diametro, 2-4-spermum. (*Ex exempll. plur. exsicc.*)

Hab. In arenosis circa Kimberley, Griqualand West, alt. 1250 metr., flor. Nov., *Bolus*, No. 6802; *Dr. Marloth* in *Herb. Norm. Austr.-Afr.* No. 408! Prope flum. Vaal, Nov. (1811), *Burchell*, 1782! (*fide N. E. Brown*).

This comes near to *C. spinosa*, Hochst., but Mr. N. E. Brown informs me that it "differs in habit, by its larger flowers, and globose pod," to which may be added that the pod is distinctly stalked and has fewer seeds; I opened six and found them to contain from two to four. It is tolerably abundant about Kim-

berley, growing even in the wider streets. To Dr. Marloth, my colleague (Prof. MacOwan) and myself are indebted for a good supply gathered subsequently, for distribution in the Herb. Normale.

ARGYROLOBIUM MEGARHIZUM, *Bolus*, n. sp. Tota sericeo-pubescens, paginis superioribus foliorum, petalisque exceptis. Caules plures ("e radice tuberosa magna," fide beato collectore), suffruticosi, erecti, virgati, ramosi, 1–1½-pedalis, ramis ramulisque striatis; stipulæ setaceæ vel subulatæ, minimæ, caducæ; folia pauca, petiolis 5 millim. longis; foliolæ lineares vel lineari-oblongæ, sæpe complicatæ, acutæ, venosæ, 2–3 centim. longæ, 3–5 mm. latæ; racemi terminales laxe 2–7-flori, pedicellis 5 mm. longis, bibracteolatis; flores 1·0–1·2 cm. longi; calycis labium inferius breviter et obtuse 3-dentato; vexillum late obovatum; alæ oblongæ; carina obtusa; legumen lineare, erectum, acutum, villis badiis adpressis dense obtectum, 3·0–5·5 cm. longum, 3·0–3·5 mm. latum. (*Ex exempll. plur. exsicc.* No. 5635 *ut infra.*)

Hab. In planitiebus arenosis circa Pretoria, "Transvaal Republic," fl. Oct., legit *J. H. MacLea.* Herb. propr. No. 5635.

This species would appear to be best placed between *A. tuberosum*, Eck. & Zey., and *A. polyphyllum*, Eck. & Zey. It is a stouter plant, much more branched and leafy than the former; the flowers also are larger and dry pale, those of *A. tuberosum* drying black; the teeth of the calyx-lobes also are almost obtuse, not acuminate. From *A. polyphyllum* it is distinguished by its rather less leafy character, narrower linear (not obovate) leaflets, and the more obtuse teeth of the calyx-lobes.

COMPOSITÆ.

SENECIO SOCIORUM, *Bolus*, n. sp. Caules plures e rhizomate incrassato, frutescentes, erecti vel subdecumbentes, 1–2-pedales, laxe foliosi, striati, tenuiter araneoso-tomentosi, demum glabrescentes, sursum dichotome paniculati; folia glabra subpauca internodiis longis, elliptica ovata vel lanceolata, obtuse acuta, subsessilia, calloso-serrulata, venis elevatis (in sicco) reticulatis pellucidis 3·0–4·5 centim. longa, 1·0–2·5 cm. lata, superioribus in bracteas angustas acuminatas abeuntibus; corymbus laxe ramosus 4–12-capitulatus, pedunculis suberectis 3–10 cm. longis sparse bracteatis; capitula radiata oblonga vel subturbinata, 1·2–1·6 cm.

longa, apice 1·0–1·4 cm. lata; involucrum 12–14-phyllum, bracteis oblongis acutis, margine submembranaceis, apice pubescentibus, basi araneosum parce calyculatum, calyculis lineari-subulatis; flores radii 3–5, ligulis oblongis 1·0–1·2 cm. longis, lineis 9–11 striatis; flores tubulosi circa 28, acute 5-dentati, involucro parum longiores; stylus alte bifidus, ramis revolutis truncatis; achænia (immatura) striata setulosa, 3 millim. longa. (*Ex exempll. plur. viv.*)

Hab. In clivis inter frutices deustos in convalle "Mitchell's Pass" dicta, alt. 450 metr., mense Aprili, anno 1885, legerunt *MacOwan* et *Bolus.* No. 5434 *Bolus* in herb. Kew, &c. *Herb. Norm. Austr.-Afr.* No. 386.

This has the leaves, and perhaps also the habit, of *S. crenatus*, Thunb. I say perhaps, because our specimens are a new growth from burnt-off stumps, and the normal habit may be different. But the inflorescence, the heads (which are about the size and shape of those of *S. asperulus*, DC.), and the flowers, differ very much from those of the first-named species. The flowers of ray and disk are a bright orange-yellow. It was growing copiously where found.

SENECIO NAMAQUANUS, *Bolus*, n. sp. Frutex robustus, ramosus, 3–4-pedalis. Ramuli ultimi patentes, striati, foliosi, griseo-tomentosi, sursum glabri, 4 millim. diametro; folia pinnatipartita vel bipinnatipartita, subtus tenuiter cinereo-pubescentia, superne glabrescentia, marginibus reflexis, 8–10 centim. longa, lobis 2–3 linearibus patentibus, sæpe cum rhachide irregulariter lobatis vel dentatis; corymbus late divaricatus, 16–20-capitulatus, bracteis linearibus vel rarius pinnati-partitis; pedunculi 1·5–2·5 centim. longi, basi bracteati; capitula late campanulata, 1·3 cm. longa, apice 1·8-lata, calyculis plurimis linearibus apice incurvis prædita; involucri bracteæ lineares vel lineari-lanceolatæ acutæ apice nigro-punctatæ, nervatæ, margine scariosa, floribus disci breviores; flores flavi, ligulati circa 5, tubulosi plurimi; achænia immatura teretia tenuiter sericea. (*Ex exempll. plur. exsicc. ut infra.*)

Hab. In saxosis prope Kookfontein, Namaqualand Minor, circa 900 metr. alt., fl. Sept., legi, anno 1883. No. 6546 in herbb. meo, Kewensi, &c.; *Herb. Norm. Austr.-Afr.* No. 422.

Very near to *S. cinerascens*, Ait., differing by its more robust habit, larger corymb, and, according to Jacquin's figure quoted for that plant by DeCandolle, by the differently shaped heads, which are in that species constricted in the middle, and have very few calycles.

SENECIO ALBOPUNCTATUS, *Bolus*, n. sp. Herba perennis, basi lignosa, glabra, decumbens, 12–16 centim. alta. Caules plures subherbacei, foliosi, basi ramosi, ramulis striatis; folia inferiora pinnatipartita, acuta, sessilia, subcarnosa, patentia, 4 cm. longa, lobis 3–4 linearibus 0·5–1 cm. longis, acutis, basin versus ad dentes reductis; superiora minora inciso-lobulata, erecta, suprema in bracteas integras abeuntia, apicibus callo albo nitido undique ornatis; ramuli in pedunculos 1-capitatos, parce bracteatos, 5–6 cm. longis desinentes; capitula suboblonga, 1·3 cm. longa, apice 1·5 cm. lata, calyculis subulatis 5–6; involucri bracteæ 12–14, lineares, acuminatæ, apice albo-calloso, margine scariosa, floribus disci subæquilongæ; flores flavi, ligulati 6, limbis patentibus 1·4 cm. longis, tubulosi plurimi; achænia vix matura dense et breve sericeo-pubescens. (*Ex exempll. plur. exsicc. ut infra.*)

Hab. In apertis prope Klipfontein, Namaqualand Minor, alt. circa 900 metr., fl. Sept., legi. No. 6544 in herbb. meo, Kewensi, &c.; No. 423, *Herb. Norm. Austr.-Afr.* 423.

Very distinct among its allies of Harvey's section *Leptolobi* by its one-headed flowering branches, and not very near to any other species with which I am acquainted.

SENECIO REHMANNI, *Bolus*, n. sp. Herba perennis, erecta, virgata, basi tantum ramosa, fere glabra, 2–3-pedalis. Rami parce foliosi striati basin versus 3 millim. diam.; folia radicalia . . . . ?; caulina inferiora linearia sursum ampliata, acuta, dentata, marginibus reflexis, sessilia, dentibus utrinque 2–3, coriacea, erecto-patentia, 3–6 centim. longa, superiora breviora erecta, suprema in bracteas integras abeuntia; corymbus laxus, 7–12-capitulatus, pedunculis elongatis gracilibus; pedicellis bracteatis circa 1 cm. longis; capitula radiata, turbinata, 9 millim. longa, basi calyculis plurimis subulatis araneosis donata; involucri bracteæ circ. 20, lineares, glabræ, floribus tubulosis parum breviores; flores flavi, ligulati 8–10, tubulosi 40–50; achænia teretia tenuiter sericea. (*Ex exempll. 2 exsicc. Rehmanniana ut infra.*)

Hab. Ad rivulum Groot Valsche R. (haud procul a flum. Gauritz), fl. Nov., *Burchell* 6539!; prope Kleine Vette River, *Burchell* 6873! In montibus circa flum. Hex, alt. inter 600 et 900 metr., fl. Jan., *A. Rehmann* (*herb. Bolus* 5755).

This appears to come nearest to *S. pubigerus*, L., but is distinct in its more lax and more corymbose inflorescence, the heads being larger and not aggregated and racemose as in *S. pubigerus*. Rehmann's specimens consist of two long branches torn off at the base, and I cannot be sure whether there were any radical leaves. [Burchell's specimens in the Kew Herbarium show that there are no radical leaves distinct from the stem-leaves; all are of the same character.—*N. E. Brown*.]

ERICACEÆ.

ERICA (§ TRIGEMMA) TETRASTIGMATA, *Bolus*, n. sp. Fruticulus humilis, glaber, ramosus. Folia 3na, lineari-lanceolata, acuta, crassiuscula, dorso sulcata, appressa, internodiis subæqualia vel parum longiora; flores 3ni, ad apices ramorum conferti, erecti vel cernui, pedicellis 3 millim. longis; bracteæ 3, lanceolatæ, subremotæ, amplexicaules, coloratæ; sepala late ovata, acuta, ciliolata, vix imbricantia, membranacea, colorata, corolla fere æqualia; corolla oblongo-urceolata, subtetragona, fauce parum contracta, limbo brevi patente, 2·5 millim. longa; genitalia inclusa; antheræ minute cristatæ; ovarium obovatum, 8-lobatum, glabrum; stylus apice 4-fidus, ramis recurvis; stigmata 4, capitata. (*Ex exempll. exsicc. plur.* sub No. 5451 *ut infra.*)

Hab. In montibus circa Houw Hoek, alt. 600 metr., fl. Oct., *Bolus* No. 5451 in herbb. Kewensi, meo, &c.

The sepals and corolla are a reddish-lilac colour. The habit and the leaves are those of the section *Lamprotes*; but the flowers are different, and it seems better placed as above, next to *E. baccans*, Linn., and *E. chlamydiflora*, Salisb.

ERICA (§ PSEUDEREMIA) BAURII, *Bolus*, n. sp. Fruticulus erectus, ramosus, hispidus pilis mollibus. Folia 4na, lineari-lanceolata, acuta, subtus glabra, circ. 2 millim. longa; flores capitati, capitulis globosis, diametro 8 millim.; bracteæ 3 sepalaque linearia, longe ciliata; corolla urceolato-globosa, fauce constricta, limbo recurvo-patente, sub lente minute pubescens, 2–3 millim. longa, sepalis parum longior; antheræ inclusæ ovatæ, breves, latissime cristatæ; ovarium globosum, hispidum; stylus inclusus, stigmate capitato. (*Ex exempll. plur. exsicc.*)

Hab. Ad margines sylvarum, Bazija Caffrorum, alt. circ. 950 metr., flor. Aprili, legit *Rev. R. Baur* No. 639.

Allied to *E. Solandriana*, Andr.; differs by its more globose corolla, shorter anthers, and very different anther-appendages. Under a lens the numerous hairs appear irregularly serrate, and shortly bifurcated at the apex; in a specimen of *E. Solandriana* which I examined at Kew the hairs were quite simple.

ERICA (§ PSEUDEREMIA) COOPERI, *Bolus*, n. sp. Fruticulus erectus, ramosus, 2–3-pedalis, ramis adscendentibus interdum flexuosis, pubescentibus. Folia 4na, lineari-lanceolata, marginibus revolutis, pilis apice furcatis ciliato-hispido, 4–5 millim. longa; flores terminales, 4ni, cernui; pedicelli breves; bracteæ lineari-lanceolatæ, acuminatæ, approximatæ, cum sepalis linearibus pilis longissimis plumosis ciliatæ; corolla ovato-urceolata limbo brevi erecto-patente, puberula, 5 millim. longa, sepalis æquilonga; antheræ inclusæ, oblongæ, cristatæ, cristis in aristam desinentibus; ovarium oblongum, truncatum, hirsutum; stylus inclusus, stigmate capitato. (*Ex exempll. exsicc. a Sutherland.*)

Hab. Ad rivulos, Natal, *Cooper*, No. 1101; Natal, sources of the Umvoti and Umgeni Rivers, 4000–5200 ft., July and August, *Sutherland*; Mid Illovo, April, *Wood*, 1890?

[Also Natal, *Buchanan*, 37; Noodsberg, April, flowers white, *Wood*, 888; Orange Free State, *Cooper*, 2528 and 3531, in Herb. Kew, *N. E. Brown*.]

The corolla appears to have been white or pale rose. Near to *E. Baurii*, but seems to be a stouter plant, and has a different corolla, anthers, and ovary. *E. Solandriana*, Andr., with a very similar corolla, has much more numerously flowered heads, shorter ovate bracts, different anthers, and simple hairs. In this species even the short hairs which clothe the branches are irregularly feathered, and those on the bracts and sepals are more compound than in *E. Baurii*. Mr. Cooper's specimens have not fully developed flowers; I describe from Dr. Sutherland's, which seem otherwise identical. Wood's No. 1890 appears to me to be the same species, but in his specimens also the flowers are undeveloped.

ERICA (§ PSEUDEREMIA) MISSIONIS, *Bolus*, n. sp. Fruticulus erectus, ramosus, pubescens. Folia 4na, lineari-lanceolata, obtusa, ciliata, adpressa; flores capitati, capitulis subhemisphæricis; bracteæ lanceolatæ, approximatæ, scariosæ, coloratæ, ciliatæ; sepala linearia colorata, ciliata; corolla urceolata, limbo erecto-patente, sepalis vix longior, circa 5 millim. longa; antheræ

inclusæ, inciso-cristatæ; ovarium tomentosum; stylus inclusus, stigmate parvo capitatus. (*Ex exempl. unico, Baur* 218.)

Hab. Ad ripas flum. Ingxu et Tsita prope sedem Missionis "Sancti Augustini" dictam, alt. circ. 700 metr., flor. Maio-Junio, *Rev. R. Baur* No. 218.

This species comes near to *E. cernua*, Linn. f., and *E. sphærocephala*, Wendl., differing from either by its shorter, more appressed leaves, larger sepals and bracts, its tomentose ovary, and its heads frequently disposed along the branches instead of being invariably terminal.

ERICA (§ PACHYSA) URNA-VIRIDIS, *Bolus*, n. sp. Suffrutex erectus, ramosus, glaber, 3–5-pedalis. Folia 4na, linearia, obtusa, erecto-patentia; flores terminales, 3ni, sæpissime longiuscule pedicellati, pedicellis 6–8 millim. longi, infra medium 3-bracteati; sepala ovata, subobtusa, 3 millim. longa, cum corolla viscosissima; corolla inflato-urceolata, limbo erecto, circa 1·3 centim. longa; antheræ inclusæ, cristatæ; ovarium oblongo-obovatum, stipitatum. (*Ex exempll. plur. viv.*)

Hab. In montibus Peninsulæ Capensis (Muizenberg &c.), alt. 250–400 metr., flor. Sept.–Mart., *Bolus* 3355. *Herb. Norm. Austr.-Afr.* No. 42.

Flowers a bright clear green! In this respect I have never seen any variation. I find it very difficult to distinguish this species by good technical characters from the old and well-known *E. physodes*, Linn. Few who know them on their native hills would regard them as conspecific; while many who have seen them only in herbaria would disapprove their separation. I shall endeavour to point out their chief differences:—

E. urna-viridis.	*E. physodes.*
Tall and lanky, 3–5 ft., with straggling, spreading branches.	Short; rarely over 2 ft.; branches very erect and approximate.
Pedicels 6–8 millim. long.	Pedicels 1–4 millim. long.
Corolla always green.	Corolla always white.
Flowers from Sept. to March.	Flowers only in the winter—July to Aug.
Zone of growth 600 to 1300 ft.	Zone of growth, 2300 to 2800 ft.

They do not grow, so far as my observations go, on the same mountain, nor have I met with them nearer than five or six miles from each other, nor anywhere else than on the Cape Peninsula, and quite possibly both species are confined to it.

Erica (§ Pachysa) adenophylla, *Bolus*, n. sp. Fruticulus humilis, erectus, ramosus, glaber, spithamæus vel ultra. Folia 3na, linearia, obtusa, planiuscula, conferta, squarroso-recurva, marginibus carinaque rigide glanduloso-ciliatis, 6–8 millim. longa; flores terni, viscosi erecti, pedicellis gracilibus 8–14 millim. longis; bracteæ 3, lineares, acuminatæ, distantes; sepala ovato-lanceolata, crassa; corolla ovato-urceolata vel urceolato-campanulata, limbo erecto obtuso, 6–8 millim. longa, sepala 2–3plo superans; genitalia inclusa; filamenta brevia, vix tertiam partem corollæ attingentia; antheræ oblongæ, muticæ, loculis alte partitis; ovarium substipitatum, obovatum, glabrum. (*Ex exempll. plur. exsicc. ut infra.*)

Hab. In clivis meridionalibus montis Houw Hoek, alt. circ. 950 metr., flor. Oct., *Bolus* No. 5453.

The flowers are a pure white. The species has nearly the flowers of *E. physodes*, but smaller and more delicate; it is also allied to *E. odorata*, Andr., having similar leaves and the very short stamens of that species.

Erica (§ Hermes?) hæmantha, *Bolus*, n. sp. Fruticulus erectus, ramosus, ramis adscendentibus puberulis. Folia 4na, linearia, dorso sulcata, lævia, adpressa vel incurva, 4–6 millim. longa; flores terminales et laterales, 4ni; pedicelli graciles, patentes; bracteæ 3, lineares, obtusæ, remotæ, coloratæ; sepala ovata, acuta, dorso sulcata, basi imbricantia, puberula, patentia; corolla urceolato-tubulosa, fauce parum contracta, limbo obtuso patente, viscidula (vel fere sicca), 7–8 millim. longa, sepala 4–5-plo superans; antheræ inclusæ, breviter cristatæ; ovarium obovatum, glabrum; stylus breve exsertus, stigmate capitato. (*Ex exempll. plur. exsicc.* No. 5344 *ut infra.*)

Hab. In clivis montium circa pagum Ceres, alt. circ. 500 metr., fl. Mart., legi, No. 5344.

Flowers blood-red. This species must come next to *E. decora*, Andr., which it much resembles, although the flowers are certainly both terminal and lateral. It has not the corolla of § *Pachysa*, with which in some technical characters it better agrees, and besides the flowers of that group are always terminal.

Erica (§ Ceramia) Tysoni, *Bolus*, n. sp. Fruticulus spithamæus, gracilis, decumbens, scabrido-hirsutus. Folia terna, lineari-lanceolata, breve petiolata, superne glabra, dorso sulcata, scabrido-hirsuta, circa 2·5 millim. longa; flores axillares, pedicellis brevibus; bracteæ 2, foliaceæ, obovatæ, subapproximatæ; sepala lanceolata, obtusa, glanduloso-ciliata; corolla oblongo-campanulata, carnea, circa 2·5 millim. longa; stamina cum stylo demum exserta, antheris scabris aristatis; ovarium glabrum. (*Ex exempll. plur. exsicc. ut infra; E. satureioides, Sond. MSS.?* in herb. Kewensi.)

Hab. In summo monte Ingeli, Griqualand orientalis, alt. 1800–2300 metr., fl. Mart., anno 1883, legit *W. Tyson*, No. 1290. *Herb. Norm. Austr.-Afr.* No. 469.

Belongs to Bentham's section *Ceramia*, and is allied to *E. planifolia*, Linn., and to *E. filiformis*, Salisb., but differs from both in its inflorescence, which is more racemose than in most of this section. Its pedicels are much shorter than those of the first-named, and the corolla is different. The subumbellate flowers and the glabrous muticous anthers of *E. filiformis* afford a sufficient distinction from that species. It appears to me to be identical with a specimen received from the Kew Herbarium marked "*Faku's Territory, South Africa, Dr. Sutherland.*" The specimens show a more mature plant than those of Mr. Tyson.

Erica (§ **Ephebus**) **Lerouxiæ**, *Bolus*, n. sp. Suffrutex ramosus, pubescenti-pilosus. Folia 3na, lanceolata, acuta, mucronata, marginibus reflexis ciliatisque, superne pubescentia, subtus fere glabra; flores 3ni, bracteis 3, lanceolatis coloratis, approximatis; sepala lanceolata acuminata, ciliata, cum corolla dense sericeo-pubescentia; corolla urceolato-campanulata, ore subconstricto, lobis erectis, circa 5 millim. longa, 4 mill. lata; filamenta ciliata; antheræ inclusæ, oblongæ, loculis alte partitis, basi cristatæ; ovarium dense sericeo-pubescens; stylus exsertus, stigmate latiusculo sed vix peltato. (*Ex exempll.* 2 *exsicc. ut infra.*)

Hab. In French Hoek, legit *Domina E. Le Roux*, in "Herb. Huguenot Seminary," No. 303.

In habit and general appearance near to *E. urceolaris*, Berg., but quite distinct by its much broader corolla, approximate bracts, &c. The flowers, including the bracts, are a creamy white, leaves greyish green.

Erica (§ **Ephebus**) **aspalathifolia**, *Bolus*, n. sp. Rami longi, dense foliosi, pilosi, 1½-pedales; ramuli brevissimi, conferti;

folia 3–4na vel sparsa, linearia, acuta, minute pubera, marginibus revolutis setoso-ciliatis, 2·5 millim. longa; flores terminales, 4ni, secus partem superam ramorum conferti, pseudo-spicam densam formantes, pedicellis 2 millim. longis; bracteæ 2 (vel 3?), lineares, foliaceæ, subremotæ; sepala linearia, herbacea, setoso-ciliata; corolla glabra, oblongo-urceolata, fauce parum contracta, limbo brevi patente, 5 mill. longa; genitalia inclusa, antheris oblongis aristatis; ovarium apice hispidum. (*Ex exempll. duobus Wood*, No. 911, *ut infra*.)

Hab. In lapidosis humidis, Noodsberg, Natal, circa 1000 metr., fl. Aprili. *J. M. Wood*, No. 911 in herbb. Kewensi, meo, &c. [*Wood*, No. 693, from Inanda, Natal, Oct., in herb. Kew, appears to be the short-stamened state of this plant.—*N. E. B.*]

The corolla is described by Mr. Wood as white, and is of a delicate, thin texture. The habit of the plant is that of *E. Alopecurus*, Harv., next to which I should place it, for though the glabrous corolla is very unusual in this section, I cannot find a better place.

Erica (§ Orophanes?) trichadenia, *Bolus*, n. sp. Suffrutex erectus, ramosus, scaber, 2–3-pedalis; ramis glabrescentibus, ramulis hirsutis. Folia 3na, linearia, acuta, marginibus revolutis, puberula, apice setis glanduliferis rigide ciliata, patentia vel squarrosa, 5–7 millim. longa; flores umbellati, umbellis 5–7-floris, pedicellis 4–5 millim. longis, basi bractea solitaria donatis; sepala herbacea lineari-lanceolata, pubescentia, glanduloso-ciliata; corolla oblongo-campanulata, sicca, limbo erecto-patente, sub lente minutissime puberula, 3–5 millim. longa, calyce duplo longior; antheræ subterminales, inclusæ, aristatæ; ovarium subglobosum, pubescens; stylus exsertus declinatus, stigmate capitato. (*Ex exempll. plur. exsicc. sub num.* 5297.)

Hab. In clivis montium circa Mitchell's Pass, alt. 600 metr., fl. Oct., anno 1882, legi. No. 5297 in herbb. Kewensi, meo, &c.

The flowers are a light flesh-colour. The habit and leaves are very similar to those of *E. strigosa*, Sol., but it is distinguished in the section by its ternate leaves, and rather long, and long-stalked, flowers. The anthers are nearly if not quite terminal; and if it were not that this is the case with several species otherwise united with very diverse groups, the present plant might go with the section *Desmia.* From *Ephebus* it is separated by its oblong corolla and long pedicels.

ERICA (§ **LEPTODENDRON**) **TRACHYSANTHA**, *Bolus*, n. sp. Fruticulus erectus, gracilis, spithamæus, hirsutus, simplex vel basi ramosus. Folia 3na, lanceolata, acuta, breviter petiolata, marginibus amplis reflexis, supra glabra, subtus hispida, ciliata, 4–5 millim. longa, 2–2·5 millim. lata; flores subsolitarii, terminales, pedicellis nutantibus tomentosis, 1·3 centim. longis, basi bracteis 3, lanceolatis, minimis, donatis; calyx ad basin fere 4-partitis, segmentis ovatis acutis, 4 mm. longis, pilis albidis dense tomentosis; corolla tubulosa, glabra, limbo erecto plicato obtusissimo, 6 millim. longa; stamina inclusa, brevia, ovarium æquantia, antheris lanceolatis, acuminatis, muticis, scabris; stylus gracilis inclusus vel interdum exsertus, stigmate capitato; ovarium subconicum, tomentosum. (*Ex exempll. plur. exsicc. sub num.* 2387 *ut infra.*)

Hab. In clivis montosis, Kammanassiebergen, prope Avontuur, fl. Nov., legit *H. Bolus* (anno 1870), No. 2387 in herbb. Kewensi, &c.

Closely allied to *E. Passerinæ*, Linn. f., from which it differs as follows:—

E. trachysantha.	*E. Passerinæ.*
Habit simple or only branched at base.	Habit much branched.
Leaves ovate, acute, flat, glabrous above, with long hairs below.	Leaves oblong, obtuse, thick, shortly tomentose all over.
Pedicels 1·3 cm. long.	Pedicels 6 millim. long.
Sepals tomentose, with long hairs.	Sepals with short, matted indument.
Limb of corolla muticous.	Limb of corolla apiculate.
Anthers lanceolate, acuminate.	Anthers oblong, cells divaricate above.

My analysis of *E. Passerinæ* is from Forsyth's specimen in herb. Kew, so marked by Bentham. Those of Masson are younger, but appear to be identical. I have given the differences between the two species above in some detail because they are both very distinct, not only in the group (with which they are indeed somewhat artificially united) but also in the genus; there being no other species, so far as I know, which they resemble.

ERICA (§ **MELASTEMON**) **CAFFRORUM**, *Bolus*, n. sp. Suffrutex erectus, ramosus, glaber, 3–4-pedalis. Folia 4na, linearia vel lineari-lanceolata, acuta, dorso sulcata, erecto-patentia, 4–5 millim. longa; flores terminales, 4ni, in ramulis brevissimis confertis sæpius cernui; pedicelli flores subæquantes, basin versus bracteis 3 linearibus donati; sepala late obovata, acuta, carinata, scariosa, colorata, quam corolla duplo breviora; corolla oblongo-campanulata, limbo erecto tubo vix breviore, 3 millim. longa; antheræ inclusæ, oblongæ, scabridæ, minute biaristulatæ; ovarium glabrum; stylus exsertus, stigmate capitato. (*Ex exempll. 2 exsicc. ut infra.*)

Hab. Bazija, Kraffraria, *R. Baur*, No. 507; in ditione Queenstown, *I. Cooper*, No. 211 in herbb. Kewensi, &c.

Flowers, according to Cooper, "pinkish white." Habit and general appearance resemble *E. leucanthera*, Linn. f., but the leaves are 4-nate. In floral characters nearest to *E. stenantha*, Klotzsch, but the flowers are shorter, the corolla much less deeply cut, and the leaves and habit different.

ERICA (§ EURYSTOMA ?) BROWNLEEÆ, *Bolus*, n. sp. Fruticulus robustus, erectus, 1–4-pedalis. Ramuli puberuli, subvirgati; folia 4na, subulata, erecta, dense imbricata, 9 millim. longa; flores terminales, 4ni, 5 millim. longi, pedicellis nutantibus, cano-pubescentibus, 3 millim. longis; bracteæ subapproximatæ, ovatæ, acutæ, membranaceæ, coloratæ; sepala late elliptica vel fere orbicularia, acuta, apicem versus carinata, basi imbricantia, viscidula, corollæ æquilonga; corolla tubulosa, limbo obtuso parum expanso, tubum æquante; stamina subexserta, antheris oblongis, scabris, cristatis; ovarium hemisphæricum, sulcatum, glabrum; stylus validus, stamina excedens, stigmate clavato. (*Ex exempll. plur. exsicc. sub num* 2858 *Tyson, ut infra.*)

Hab. In graminosis ad margines sylvæ "Perie Forest" dictæ, Kraffraria, in "Regione Orientali" Coloniæ Capensis, alt. circa 760 metr., fl. Febr., legit *Miss Brownlee*, No. 2858, in herbb. W. Tyson, Kewensi, Bolus, &c.

The sepals and corolla are white. The habit something like that of *E. triflora*, L., or of *E. vespertina*, Linn. f. In floral structure it approaches most nearly to the last named, but the leaves are longer, the flowers larger, the bracts broader, the sepals longer in proportion to the corolla, the limb of the latter more connivent and not reflexed. Its 4-nate leaves seem to separate it from either of the sections *Eurystegia* or *Eurystoma*, while yet it unites certain floral characteristics of both.

ERICA (§ POLYCODON) ERIOCODON, *Bolus*, n. sp. Fruticulus erectus, subrobustus, ramosus, pubescens; rami ramuli foliaque pube brevi, cum pilis badiis interdum glanduliferis intermixtis, obtecta; folia 3na, lanceolata, plana, subacuta, marginibus reflexis, cinerascentia, 3 millim. longa; flores terminales 3ni, pedicellis corolla brevioribus; bracteæ 3, lineares, subremotæ; sepala ovata, subobtusa, herbacea; corolla campanulato-globosa, limbo inflexo, viscoso-pubescens, 2·5 millim. longa; antheræ inclusæ, obcordatæ, muticæ; ovarium hirsutum; stylus breve exsertus, stigmate capitato. (*Ex exempll. 2 exsicc. sub num.* 5190.)

Hab. In clivis meridionalibus montis Winterhoek Tulbaghensis, alt. circ. 450 metr., fl. Nov., legi. No. 5190 in herbb. Kewensi, meo, &c.

Corolla pale dull red, leaves ashen grey. The general appearance resembles that of *E. patens*, Andr., but the calyx is very different. It is also something like *E. bicolor*, Thunb., but differs in several characters. In some respects it approaches the section *Ephebus*, but here again the shape of the corolla is alien.

ERICA (§ ARSACE) INOPS, *Bolus*, n. sp. Suffrutex erectus, ramosus, 2–3-pedalis. Rami adscendentes, glabrescentes, ramuli pubescenti-hirti; folia 3na, lineares, dorso sulcata, scabro-hispida, 4 millim. longa; flores subterni, numerosi, 3–4 millim. longi; bractea unica, approximata, ovata, acuta, subamplexicaulis, colorata; sepala ovata, colorata; corolla globoso-campanulata, calyce parum longior, ore aperto, limbo tubo multo breviore; antheræ inclusæ muticæ, glabræ; ovarium apice hispidulum; stigma peltatum. (*Ex exempll. plur. exsicc. sub num.* 3719.)

Hab. In montibus Peninsulæ Capensis, alt. 430–750 metr., flor. Julio–Aug. *Bolus* 3719; *Herb. Norm. Austr.-Afr.* No. 50.

The sepals, corolla, and bract are whitish. Habit, leaves, and general appearance that of *E. hispidula*, L., with which I expect it will be found mixed in many herbaria. But it is readily distinguished by its single sheathing bract. *E. unibracteata*, Klotzsch, which I have not seen, must be a different plant, judging from the description, and, besides, comes from the extreme eastern districts. Our plant is not uncommon, and occurs both on the Table and Muizenberg Mts.

ERICA (§ ARSACE) NATALITIA, *Bolus*, n. sp. Fruticulus gracilis, erectus, ramosus, ramis adscendentibus cano-pubescentibus. Folia 3na, linearia, glabra vel sub lente minutissime puberula, circa 3 millim. longa; flores numerosissimi umbellatim conferti, minimi; bracteæ 3, remotæ; sepala deltoidea, pubescentia, ciliata, colorata, interdum subinæqualia; corolla fere globosa, limbo connivente, glabra, circa 1 mill. longa; antheræ 7–8, inclusæ, liberæ, muticæ; ovarium globosum, glabrum; stylus longe exsertus, stigmate obconico, magno. (*Ex exempll. exsicc.* 2, *Wood* 990.)

Hab. Natal, Indivedive, *Wood* No. 990. [Natal, ridges occasionally snowed, 4000–5000 ft., Sept., *Sutherland*; in herb. Kew. —*N. E. Brown.*]

In habit this resembles the smaller-flowered specimens of *E. floribunda*, Lodd.; but the flowers, which are pink according to Mr. Wood, are still smaller (perhaps the smallest in the genus) and are besides differently shaped.

PHILIPPIA TRISTIS, *Bolus*, n. sp. Fruticulus gracilis, erectus, ramosus, fere glaber. Folia 3na, linearia, obtusa, erecto-adpressa, viscidula, juniora ciliolata, 2–3 millim. longa, internodiis parum longiora; flores terminales, solitarii vel 2–3ni, cum pedicellis circa 3 millim. longi; sepala ovata, subinæqualia, subacuta, colorata, corolla dimidio breviora; corolla campanulato-globosa, limbo obtuso, circa 1·5 mm. longa; stamina inclusa, filamentis brevissimis basi dilatatis connatis, antheris late ovatis basi cohærentibus; ovarium globosum, stylus gracilis, exsertus, obconicus, stigmate excavato vix peltato. (*Ex exempll. paucis exsicc. sub num.* 2594 *ut infra.*)

Hab. In clivis graminosis montis Koudveld inter Graaff Reinet et Murraysburg, in Coloniâ Capensi, alt. circ. 1400 metr., flor. Dec., legit *H. Bolus* (anno 1872), No. 2594 in herbb. Kew. &c.

This has somewhat the appearance and habit of *Ericinella passerinoides*, mihi, but both the leaves and flowers are less densely crowded. The sepals are much more nearly equal than is usually the case in this genus.

On Nuclei in *Oscillaria* and *Tolypothrix*.

By Dukinfield H. Scott, M.A., Ph.D., F.L.S.

[Read 16th June, 1887.]

(Plate V. figs. 1–4.)

In all recent classifications of the Vegetable Kingdom the class of Schizophyta, including, on the one hand, the "blue-green Algæ," and, on the other, the Bacteria, has been sharply separated from all other plants. The chief grounds on which this separation is based are three in number:—1st. The absence in the Schizophyta of any sexual reproduction; 2nd. The absence of distinctly differentiated chromatophores; and 3rd. The absence of nuclei. It is with the last point alone that we are now concerned. Statements alleging the existence of a nucleus in these plants have indeed been made from time to time. Thus Schmitz once believed that he had found a nucleus in *Oscillaria* itself and other Cyanophyceæ; but he afterwards found reason to give up this view. Zopf made similar assertions with regard to *Phragmonema* and an allied genus. Here, however, it remained uncertain whether the bodies detected by him were really nuclei or simply vacuoles.

Since the exhibition of the under-mentioned specimens, the writer's attention has been called to a paper by N. Wille *, in which the existence of a nucleus in *Tolypothrix lanata* is maintained on the ground of very careful observations in which various staining-reagents were used. So far as it is possible to judge from a paper in which there are no figures in illustration of this point, it appears that Wille had really solved the problem. Indications of division-stages also seem to have been seen by him. There is, however, an absence of satisfactory detail from the paper. Wille's work appears to have attracted little or no attention, in spite of its considerable merit. Two years later Hansgirg †, in the same publication, asserted that both nuclei and chromatophores are present in *Glœotheca* and other forms, though he did not find them in *Oscillaria* or its near allies. His figures, however, throw no light whatever on the subject. Within the last few weeks a series of papers by Zacharias, which is not yet complete, has appeared in the 'Botanische Zeitung.' His subject is the nucleus generally; and it is only a small part of his whole work with which we are directly concerned. To previous work by this author we owe a large part of our knowledge of the chemistry of the nucleus.

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* Berichte d. deutschen botanischen Gesellschaft, 1883, p. 243.

† Berichte, 1885, p. 18.

The method used by him in that part of the investigation which is of immediate interest in this connexion was to treat the objects first with ether-alcohol to remove fat, and then to digest in pepsine solution, subsequently making use of various staining-reagents. By this method Zacharias was able to demonstrate, both in the cells of Yeast and in those of *Oscillaria* and *Tolypothrix*, the existence of a body having the coarsely fibrous structure with which histologists are familiar as characterizing the so-called "knot-stage" of the nucleus of the higher plants. The structure in question closely agreed in its reactions with the filamentous (chromatin) portion of undoubted nuclei. As we have seen, it resisted the action of pepsine, while, on the other hand, it was soluble in such reagents as dilute solution of common salt. In its staining peculiarities the body in question also showed a nuclear character. The tests applied by Zacharias will probably be regarded as satisfactorily establishing the existence of a real nucleus in each cell of the plants in question. In *Tolypothrix* the body which gives the nuclear reactions is already visible in the natural state without any treatment whatever.

The exhibition now described is confirmatory of Zacharias's results; but the methods employed were different. It must here be expressly stated that the nominal exhibitor can only claim a very small portion of whatever credit may belong to the demonstration. The preparations were made by a lady, Miss H. V. Klaassen, working in the Jodrell Laboratory at Kew; and to her is due, not only the actual manipulation, but also, to a great extent, the elaboration of the methods. The drawings shown are also by her hand.

The plants so far investigated comprise three species of *Oscillaria* and *Tolypothrix coactilis*. The preparations actually shown were prepared as follows:—"*Oscillaria* No. 1" was treated for five minutes with methylated ether and then stained for four minutes with Kleinenberg's hæmatoxylin. The specimen was then mounted by the usual process in Canada balsam. In the middle of each cell a deeply stained roundish body is seen which has a distinctly fibrous structure, comparable, as already stated, to the well-known "knot-stage" of the ordinary nucleus, as seen, for example, in pollen mother-cells just before division. In some of the cells this fibrous body is broken up into a small number of portions. In all the latter cases indication of division of the cell by the ingrowth of a new transverse wall are found. In a few specially favourable examples indications of colourless striæ, suggesting the idea of "achromatin fibres," could be observed, connecting the portions of the nuclear structure, and traversing the region when the new cell-wall was not yet complete. The small number of segments into which the chromatin thread breaks up suggests a comparison with such animal nuclei as that in the ovum of *Ascaris.*

The other preparations shown, "*Oscillaria* No. 3" and *Tolypothrix coactilis*, were both prepared by the following method:—Treatment for two hours with picro-nigrosin solution was followed by immersion in saturated solution of chloral hydrate for two minutes, the filaments being subsequently mounted in pure glycerine.

In "*Oscillaria* No. 3" the knot-like nuclei are very clear. Each nucleus is somewhat contracted, leaving a clear space between the chromatin thread and the general protoplasm of the cell. This phenomenon was long ago detected by Strasburger in the knot-stage of the nuclei of spore and pollen mother-cells. In this preparation division-stages are especially frequent, and far clearer than in "*Oscillaria* 1." The signs of achromatin fibres are more marked. It is hoped that the important subject of caryokinensis in these plants may be more fully dealt with in a future paper. It will clearly be of the greatest interest to know how far these phenomena show an agreement with those which are now so well known in the case of the higher plants.

The *Tolypothrix* shows the same general characters, the slightly contracted fibrous nuclei coming out with remarkable clearness. Here also some indications of division may be observed.

It may be mentioned that other methods than those used for the preparations exhibited have been employed with similar results. It is unnecessary to go into these in detail. In all cases the same structure was shown, only slight differences in the amount of contraction of the nucleus being observed. In "*Oscillaria* 2," probably *O. princeps*, the nuclei are of an elliptical outline, and show the fibrous structure very plainly.

The criticism which is most likely to be made on these observations, and which has indeed been actually suggested by a distinguished botanist, is this: Is it not possible that the supposed nuclei are really products of coagulation due to the reagents employed? It might be supposed that the more granular portion of the cell-contents may become separated from the rest and accumulate in a central mass.

The answer to this objection is, I think, threefold:—

1. The granular protoplasm can still be clearly seen surrounding the "nucleus."

2. The existence of division-stages in the central body, accompanying the division of the cell as a whole, points clearly to a truly nuclear nature.

3. In *Tolypothrix* the same bodies which present the characters described can be seen in the living state before any artificial treatment has been applied.

To this it may be added that the observations just described must be taken in connexion with the chemical tests applied by Zacharias, which go so far to establish the character of the bodies in question as nuclei, agreeing in their reactions with the undoubted nuclei of the higher plants.

In conclusion, a few words may be said on the general bearing of the facts observed.

In spite of the scattered observations cited at the beginning of this paper, it has been the received doctrine up to the present time that the Schizophyta contain no nuclei; though it has been held that isolated granules of the chemical nature of nuclein may occur in their cells. It will only be necessary to quote two authorities. Strasburger, in his classical work 'Das botanische Practicum' (1884), p. 367*, states that the Schizophyceæ and the Schizomycetes agree in being *destitute of nuclei* and of definite chromatophores. Goebel ('Outlines of Classification,' Engl. ed., p. 20, 1887), asserts that "no cell-nucleus is found either in the Cyanophyceæ or in the Schizomycetes." If the present observations, in conjunction with those of Zacharias and others, be established, and extended to other members of the group, these statements must fall to the ground. The bearing of this is twofold.

1. The conclusion is important with reference to the general theory of the cell. In all plants with nuclei we have good grounds

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* Also in the 2nd ed., 1887.

for believing that these are essential in some way for the life and development of the cell, though their actual functions remain unknown. This has, as is well known, been experimentally proved by Schmitz in the case of the multinucleate cells of certain *Siphoneæ.* The question whether there are any plants which are normally destitute of these structures is thus obviously one of great physiological interest.

2. The subject is important from a systematic point of view. The separation of the Schizophyta from the rest of the vegetable kingdom has, as we have seen, depended mainly on three negative characters; for the peculiarity in the pigment of the Cyanophyceæ is not a point on which great weight can be laid. Of the characters in question, that regarding the absence of sexual reproduction is the least important; for there are many of the higher plants in which observation has hitherto failed to reveal any such process. The absence of nuclei and of chromatophores are points of almost equal importance; though the former will probably be regarded as the more weighty. That this distinction has been, even in some instances, broken down must be regarded as tending in an important degree to bring the Schizophytes into closer relation with other Thallophytes.

It may perhaps be said, without presumption, that the results attained in the Cyanophyceæ tend to obliterate the line of demarcation between these plants and the true Algæ. As regards the occurrence of nuclei in the Bacteria, nothing is yet known.

DESCRIPTION OF PLATE V. (Figs. 1–4.)

A.

Fig. 1. *Oscillaria*, sp. ("No. 1"), prepared by ether—hæmatoxylin—Canada-balsam method. Segmentation indicated at *a*.

Fig. 2. *Oscillaria*, sp. ("No. 2," probably *O. princeps*), prepared by ether—hæmatoxylin—glycerine method. The details are only shown in a few of the cells.

Fig. 3. *Oscillaria*, sp. ("No. 3"), prepared by picronigrosin—chloral-hydrate—glycerine method. Division-stages shown in several of the cells.

Fig. 4. *Tolypothrix coactilis*, prepared by ether—hæmatoxylin—glycerine method.

All the figures magnified about 800.

On a Species of *Balanophora* new to the Japanese Flora.

By TOKUTARO ITÔ, F.L.S.

[Read 16th June, 1887.]

(PLATE V. figs. 5–8.)

OUR knowledge of the flora of Japan has progressed since the publication of the conjoint work of MM. Franchet and Savatier, by the continued researches of many men of science, both in the west and in the east, but more especially by the laborious studies of that competent authority on the Eastern Asiatic Flora, Dr. C. J. Maximowicz of St. Petersburg. Under these circumstances, all that remains requisite is the compilation of a complete flora of Japan in some such form as Bentham's 'Flora Hongkongensis,' or Sir J. D. Hooker's 'Flora of British India' (the latter an elaborate work still in course of publication), which is not an easy task to undertake. With no such complete flora at present, botanists may welcome even one fact towards our knowledge of the flora of Japan, if of such a nature as to make known more or less striking features in the geographical distribution of plants.

Having taken great interest in the numerous papers which have lately appeared on the debated Order Balanophoreæ, among which I may mention Dr. E. Zimmermann's "Beitrag zur Kenntniss der Anatomie der *Helosis guyanensis*" (Flora, 1886), Dr. H. Trimen's "Notes on *Balanophora Thwaitesii*," Eichl. (Journ. Linn. Soc., Bot. vol. xxii. 1886, p. 330), and especially the noteworthy memoir on new species of *Balanophora* and *Thonningia* by Mr. W. Fawcett (Trans. Linn. Soc., Bot. ser. 2, vol. ii. 1886, p. 233), I am induced to make a few statements, of a more or less imperfect character, on the occurrence of a plant in Japan belonging to this remarkable Order, which had been previously unnoticed by European botanists, since I have paid special attention to it for some years, in order to come to a definite conclusion. I have not, however, made any previous attempt to publish my remarks on this subject, not only from the scantiness of materials, but also because I wished to wait until my observations were complete, and, if possible, at the same time to take some notice of the observation of certain anatomical as well as physiological characters of this interesting organism.

Since L. C. Richard, in 1822, established the Order Balanophoreæ in his remarkable "Mémoires sur une nouvelle Famille des Plantes, Balanophorées" (Mém. du Mus. Hist. Nat. vol. viii.), these plants, by their singular morphological characters, parasitic habit, physiological significance, and the absence of green chlorophyll, have attracted the attention of many botanists; and the elaborate monographs of Griffith [*], Hooker [†], and lastly of Eichler [‡] have shown the complexity of the subject. Minute anatomical and physiological observations at the same time were by no means neglected by botanists, the chief exponents of which are Junghuhn [§], Unger [‖], Göppert [¶], Weddell [**], Hofmeister [††], Solms-Laubach [‡‡], and Beccari [§§]. Instead of entering here, however, into details on this subject, I refer simply to the above works, which are the principal contributions to our knowledge of Balanophoreæ.

Turning now to the consideration of the geographical distribution of this Order in Eastern Asia, we find the species described by Sir J. D. Hooker from Hongkong under the name of *Balanophora Harlandi* (Trans. Linn. Soc. vol. xxii. 1859, p. 426), authentic specimens of which I have been able to examine at Kew. No observation, however, was recorded previously, so far as I am aware, as to the occurrence of any plant of this Order in Japan.

In July 1883, whilst engaged in collecting plants on Mount Amagi, in the province of Idsu, which forms a peninsula extending in a south-easterly direction on the principal island of Japan, Mr. Ohkubo, of Tokio University, was fortunate enough to find, in the shelter of the forest, a parasitic plant of somewhat remarkable form. This plant consists of an aggregation of globular fleshy bodies, each with its apical part formed into a short scaly protuberance. These bodies, eight in number, are of light-yellowish brown; the scales which enclose the protuberances being, however, brown in colour. About an inch apart there is a minute body, which seems to be one of the globular bodies in a very young state. Unfortunately the specimen found was in so early a state of development that examination of its anatomical structure was but of slight value for its systematic determination. But from its external appearance, it may readily be inferred that this plant belongs to the genus *Balanophora*. An illustration of this specimen will be found in 'Gakugei Shirin' (n. 77, p. 583), a monthly journal, published under the auspices of Tokio University. A second specimen was discovered by Mr. Makino, one of my local correspondents in Japan, in a district in the province of Tosa, in the island of Sikoku, a short account of which will be found in a Japanese scientific journal, 'Tōyō Gakugei Zasshi' (vol. iii. p. 450, 1886). Though the specimen found in the latter place was only a female plant, it is extremely probable that it is identical with that obtained from Amagi-san.

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[*] Trans. Linn. Soc., Bot. vol. xx. 1851. [†] *Loc. cit.* vol. xxii. 1859.

[‡] Eichler, in De Candolle's 'Prodromus,' vol. xvii. 1873; and in Martius's Flora Brasil. fasc. 47.

[§] Nova Act. Acad. Cæs. Leop.-Carol. vol. xviii. 1839, Suppl.

[‖] Ann. des Wiener Mus. ii. 1840.

[¶] Nova Act. Acad. Cæs. Leop.-Carol. vol. xviii. 1841, Suppl.

[**] Ann. Sci. Nat. sér. 3, vol. xiv. 1850.

[††] Abhandl. d. k. Sächs. ges. d. Wiss. Bd. vi. 1859.

[‡‡] Pringsheim's 'Jahrbücher,' Band vi. 1867–1868.

[§§] Nuovo Giorn. Bot. Italiano, vol. i. 1869.

On examining the Herbarium at Kew, I was delighted to find some specimens of *Balanophora* collected by C. Wright in the Riukiu Islands. This is probably the same plant represented in a botanical work on Riukiu plants, entitled "Sitsumon Honzo" (Gwaihen, vol. i. fol. 12)[*]. These specimens seem to me to agree in every respect with those which I have already mentioned from the two localities in Japan. Although I do not like to rush to conclusions, I cannot but consider, so far as our present knowledge is concerned, that there is a very great probability that the plants collected in Amagi-san and in the island of Sikoku, together with those from Riukiu Islands, belong to one and the same species.

Thus, at present taking the view that all the plants I mentioned are identical, I proceed to ascertain whether the specimens represented at Kew throw any light upon the subject under consideration. Fortunately the Riukiu specimens contained in the Herbarium represent both the male and female plants. Entering briefly into the specific determination of the plant in question, it may be pointed out that the male flowers of the Riukiu specimens, though imperfect, seem to represent three anthers, each bilocular, which proves their affinity to the *Balanophora dioica*, Wall., group. Now, besides *B. dioica*, there occurs a nearly allied species known as *B. polyandra*; and the difference between the two species is considered to be scarcely recognizable, since so competent an observer as Sir J. D. Hooker * says:—"I have frequently not been able to distinguish female specimens of this (*B. polyandra*) from those of *B. dioica*." The difficulty of distinguishing the two species does not seem to depend entirely on their close resemblances, but also on their variability, *B. dioica* having been described by Prof. Eichler † as "*planta magnitudine variabilis*." The distinction between the two species, however, is founded entirely on the diversity of the stamens, namely the anthers in those of *B. dioica* are bilocular, while in *B. polyandra* they are multilocular. Depending principally upon the above determinations, in an examination of the male flowers of Riukiu specimens, perhaps we may not be far wrong in presuming that the plants we found in Japan are probably *B. dioica*, Wall. The only difficulties which I cannot pass over without mention, are, that in our Riukiu specimens the number of the bracts of the peduncle is rather fewer, and they are loosely placed and irregularly imbricate as we generally observe them to be in *B. polyandra*, while in *B. dioica* the imbrication is remarkably regular; and that the capitulum of the Riukiu specimen approximates more in shape to *B. polyandra* than to *B. dioica*. By comparing our plant with other species, it differs essentially from *B. elongata* by its tubular rhizome, the latter having it elongate, from *B. Harlandi* by its non-globose capitulum, and from *B. involucrata* in other respects.

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[*] An illustrated Flora written by a native botanist of Riukiu Islands. Maximowicz has already made the following allusion to this work in 'Mélanges Biologiques tirés du Bull. de l'Acad. Imp. Sci. de St. Pétersbourg,' t. xi. 1883, p. 763:—"Sitsumon Honzo, Gwaihen, *i. e.* quæstiones de plantis Japonicis secundum figuras in Japonia ad naturam delineatas viris doctis Chinæ propositæ, cum eorum responsis, editæ ab Tsju Dzan Goshidzen e Liukiu, 5 voll. in 8vo, 1837."

With regard to the distribution of *B. dioica*, I have been able to examine the following specimens, all of which are contained in the Herbarium at Kew:—

India: Sikkim, alt. 4000–7000 ped. (*Sir J. D. Hooker*, ♂ et ♀); Khasia, alt. 3000–5000 ped. (*Sir J. D. Hooker*, ♂ et ♀, *Dr. Wallich* 1849, ♂); Nepalia (*Herb. East Ind. Comp.*, ♂, 1821).

The allied species, *B. polyandra*, is represented from various localities, some of which may be given thus:—

India: Himalaya orient. (*Herb. Griffith*, n. 2435, ♂); Sikkim, alt. 5000–7000 ped. (*coll. Sir J. D. Hooker*, ♂ et ♀).

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* Trans. Linn. Soc., Bot. vol. xxii. 1859, p. 47.

† De Candolle's 'Prodromus,' xviii. pp. 145 & 149.

Bringing now my remarks on the Japanese *Balanophora* to a conclusion, I hope that my statements, however imperfect, may throw some light upon our present knowledge as to the occurrence of *Balanophoreæ* in Eastern Asia; and that, at the same time, they will be of some slight assistance to those who may be in a position to make further observations on this interesting plant.

DESCRIPTION OF PLATE V. (Figs. 5–8.)

B.

Fig. 5. A female specimen of *Balanophora dioica*, Wall.?, collected by Mr. Makino in the island of Sikoku, Japan. Nat. size.

Fig. 6. Sketch of a female flower of the preceding on the stalk of a spadicel. Magnified.

Fig. 7. A male specimen of *Balanophora dioica*, Wall.?, collected in the Riukiu Islands. Nat. size.

Fig. 8. A male flower of the same. Slightly magnified.

On a new Genus of Orchideæ from the Island of St. Thomas, West Africa. By H. N. Ridley, M.A., F.L.S.

[Read 16th June, 1887.]

(Plate VI.)

The very interesting little terrestrial Orchid described in this paper was kindly communicated to me by Prof. Henriques, of the Botanic Gardens, Coimbra. It was obtained, with many other interesting plants, from the island of St. Thomas, West Africa, by the Portuguese Expedition in 1885.

Prof. Henriques was anxious for me to publish an account of the Orchideæ and Cyperaceæ of the expedition in the 'Boletin da Sociedade Broteriana,' in which publication have already appeared the descriptions of the remainder of the botanical collection; but on my urging the great interest of this plant, he consented to allow me to offer the publication of an account of it to the Linnean Society, in whose Journal it would be figured, and be more generally accessible to the scientific world.

Orestia, n. gen.

Herba pedalis, habitu *Microstylidis stelidostachya*; caulibus haud bulbosis, vaginis pallidis laxis tectis. Folia membranacea

2–3 inæqualia, ovata, acuta, obliqua. Scapus debilis inferne nudus, bracteis paucis exceptis. Flores parvi, patentes, haud resupinati, flavi. Bracteæ breves, lanceolatæ, acutæ. Sepalum posticum longiusculum, oblongum, lanceolatum, obtusum; lateralia breviora, ovata, falcata, labello supposita. Petala obliqua, ovata, lanceolata. Labellum sepalis brevius, obovatum, emarginatum, pulvina pubescente purpurascente in medio. Gynostemium subteres, gracile, arcuatum, superne attenuatum. Anthera terminalis filamento brevi, rostello adnata, loculi valde discreti, lateraliter mox dehiscentes. Pollinia 4, exappendiculata, elliptica, curva, transversa, ceracea, flava. Stigma tenue, profunde concavum. Rostellum latere tenue obtriangulare, apice lato obscure sinuato, antheræ adnatum et celans. Fructus ignotus.

ORESTIA ELEGANS, n. sp. (Plate VI.)

Caules 3-unciales, graciles. Folia 2–3 tenuia marginibus crispis, maximum 3 uncias longum $1\frac{1}{8}$ unciam latum. Scapus 6-uncialis, angulatus; bracteis $\frac{3}{16}$-uncialibus, ovatis, acuminatis, paucis, inferne dissitis. Racemus multiflorus, laxiusculus. Bracteæ florales lanceolatæ, acutæ. Pedicelli suberecti, $\frac{1}{8}$-unciales. Flores flavi, callo in disco labelli purpurascente.

Island of St. Thomas, West Africa, at 1200 m. Coll. Mollec.

This plant is one of no little interest on account of the remarkable structure of the column, which differs in arrangement of parts from that of any genus known to me, so that it is very difficult to establish clearly its relations with other forms.

The habit, as stated above, is just that of *Microstylis stelidostachya*. It has a stem of a few inches in height covered with thin whitish sheaths, and terminated by a tuft of oval leaves, from the centre of which rises a slender scape terminated by a lax raceme of little flowers. The sepals are dissimilar, the upper ones narrower than the lower, which are ovate and falcate, lying under the round lip, which they surpass in length. The petals are narrower than the sepals, ovate, lanceolate, and slightly curved. The lip, which is flat, has in its centre a small round pubescent cushion, over which the slender column bends. The column is cylindrical at the base, gradually tapering towards the anther, where it is dilated into a kind of hammer-head. On the front of this is a thin-walled tube forming the stigma, above which is a thin, broad, obtriangular portion which, I believe, to represent the rostellum. From in front the anther is almost entirely

invisible, except through the thin rostellum. On a back view of the column, the anther is seen to be firmly attached to the rostellum. It consists of two granular loculi quite separate from each other and dehiscing laterally (very early, for on opening a bud I found that they had already dehisced). They then form two cups, in which the pollinia lie transversely, and fall out on either side of the rostellum. The anther is attached to the column by a short but distinct filament. The pollinia are four in number, bright yellow, elliptic and curved, of a somewhat waxy, and certainly not granular, consistency. They have no appendage of any kind, and resemble most those of a *Liparis* or some such plant, and, as I have said, lie horizontally in the loculus, that is, with the long axis of each pollinium at right angles to the axis of the column. As they do not touch the rostellum at any point, it would naturally be expected that they would have no gland, which is commonly supposed to be derived from the rostellum; and this is the case. They seem to fall out of the loculi extremely readily; and from the normal position of the column it appears that the plant would have to depend for its fertilization upon the chance adherence of the pollinia to the sides of the back of some insect which comes to devour the soft purple cushion in the centre of the lip.

At first I imagined that the two loculi might represent two distinct stamens, and that the triangular body I have termed rostellum might correspond to the shield of *Cypripedium*. But on examining flowers treated with potash and glycerine, I found that there was only one fibro-vascular bundle to the anther, which runs up the back of the column, terminating abruptly between the loculi.

The front of the column is traversed by two bundles, one on either side, which terminate at the level of the stigma; but I could see none extending into the rostellum. Nor are there any traces of the lateral stamens of the outer whorl, either in the form of stelidia or of bundles. And there are also no bundles representing those of the inner staminal whorl. These, however, are commonly absent in Neottieæ, to which section this plant apparently must be referred.

For though the pollinia are in texture very different from that of a Neottiacian plant, and bear more resemblance to those of the Epidendreæ, yet the complete adnation of the anther to the back of the rostellum is only parallelled by the arrangement of the parts in some Neottieæ. In *Diuris*, for example, the anther is almost invisible from in front, on account of the large rostellum, and the anther remaining permanently attached slits longitudinally. But the pollinia in this case lie vertically, that is parallel with the axis of the column, so that their upper ends touch the viscid part of the rostellum and are thus provided with a gland. In *Orestia*, on the other hand, the pollinia are quite free from the rostellum, which appears absolutely functionless except as a means of preventing the pollinia falling on to the stigma. It is obvious, however, that to none of the other sections of Orchideæ can it be referred, for the form of the pollinia and absence of caudicles precludes Ophrydeæ; while Epidendreæ and Vandeæ have opercular anthers.

DESCRIPTION OF PLATE VI.

Fig. 1. *Orestia elegans*, n. sp. The entire plant. Natural size.
2. The flower, enlarged.
3. The column from in front. *r*, rostellum; *a*, anther; *s*, stigma.
4. The column from behind. *r*, rostellum; *a*, anther; *p*, pollinia.
5. Diagram of the course of the bundles. *r*, rostellum. *a**, fibrovascular bundle to anther; *s**, lateral bundles of column.
6. Pollen-mass.

STUDIES IN VEGETABLE BIOLOGY.—III. The Influence of Light upon Protoplasmic Movement, Part I. By SPENCER LE M. MOORE, F.L.S.

[Read 2nd June, 1887.]

(PLATE VII.)

IN the year 1856 Böhm * put on record the discovery that chlorophyll grains alter their position, collecting into masses in sunlight and moving on to the side-walls of the cells—the latter movement being effected also, but more slowly, in darkness. This matter he investigated on a rather large scale, no less than upwards of a hundred species of *Crassulaceæ* being used in the course of the experiment. Three years later Böhm † returned to this subject, but beyond noticing that the *Saxifrageæ* resemble their allies, the second memoir contains little of present interest.

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* Sitzb. der Wien. Akad. 1856, Band xxii. Heft 2.

† Ibid. 1859, Band xxvii. Heft 2.

It should be mentioned that Von Mercklin * had as early as 1850 noticed variations in the position of chlorophyll, but without attributing them to any physical agency. Shortly after Böhm, Gris † figured and described arrangements of chlorophyll grains round the nucleus, some of which must have been the effect either of light or its absence, although this was not realized by him; indeed the research had a quite different object. Gris also figured the protoplasm of etiolated plants from which the chlorophyll has disappeared, as collected upon the cells' side-walls or in their corners. To Famintzin ‡ belongs the credit of ascertaining displacements of chlorophyll to be the effect of illumination and not of heat; in a species of ***Mnium*** this author found that the grains come out on the free (surface) walls in light, and in darkness pass on to the side-walls. Shortly after this, two memoirs were published by Borodin §, in the first of which it was shown that the chlorophyll grains of prothallia, collected by sojourn in darkness on the side-walls ("Nachtstellung"), move on to the surface-walls ("Tagesstellung") in three hours, the reverse movement coming first into view not until after twenty-four hours' withdrawal from light. Moreover, Nachtstellung and Tagesstellung were likewise noticed in many Mosses, in the propagula of *Marchantia polymorpha*, and in other Hepaticæ. Borodin's second memoir, devoted to Phanerogams, marks a decided advance, since in it the effect of the intensity of light is first distinctly noticed; he showed that the chlorophyll of insolated leaves of *Lemna trisulca*, *Callitriche verna*, and *Stellaria media* is first driven upon the side-walls, but if the sunlight be still allowed to act, the grains collect in heaps in the corners of the cells. Borodin proved that this is due to light and not to heat, inasmuch as the movement will not take place in light composed of the less refrangible rays of the spectrum, but it will if, without any change of temperature, only rays of high refrangibility be used. Besides this, Borodin showed that the chlorophyll of the above types passes on to the side-walls in darkness (in the thicker portion of *Lemna trisulca* on to the wall separating the two layers as well as on to the side-walls); and also that this assumption of Nachtstellung is more rapid in a cell when injury has been inflicted on it. Next on the list comes Frank *, who in 1872 made the movements of chlorophyll the subject of a careful study. He called by the name of "Epistrophe" the distribution of the grains upon the free walls and the parts of the wall bordering on intercellular spaces, and by that of "Apostrophe" the arrangement upon the side-walls; he also confirmed the statements of his predecessors that Epistrophe is more quickly assumed from dark-caused Apostrophe than *vice versâ*. In addition to this Frank found Apostrophe to be brought about more slowly in large than in small cells, and the position of the chlorophyll grains to be largely dependent on the age and general condition of the cell. Shortly afterwards, the remarkable difference with respect to position in high and low light shown by the chlorophyll of *Selaginella Martensii* was announced by Prillieux †; and De Bary ‡, in the course of some observations made in conjunction with Strasburger on the life-history of *Acetabularia mediterranea*, noted a running together into small clumps of the grains of healthy tubes exposed for a few minutes to direct sunlight. In 1880 the subject was investigated by Stahl §, who begins his memoir with an interesting account of the effects of light upon the chlorophyll plate of a species of *Mesocarpus*, showing that the plate, set broadside on in diffused light, turns through an arc of 90° on to its edge if the illumination be strong. Stahl objects to Borodin's terms "Tagesstellung" and "Nachtstellung," remarking very appositely that the chlorophyll of many plants remains in Tagesstellung throughout the night, and that in order to move it into Nachtstellung exposure to sunlight is the only requisite. Frank's terminology likewise fails to commend itself, inasmuch as by "Epistrophe" Frank understands the arrangement of the grains upon the superficial walls, and on those parts of the walls bounding intercellular spaces, whereas in diffused light chlorophyll is disposed on the walls at right angles to the direction of incident illumination irrespective of their relation to intercellular spaces. To express the two conditions of perpendicularity to and parallelism with the incidence of light, Stahl coins the words "Flächenstellung" (corresponding with the "Tagesstellung" of Borodin) and "Profilstellung" (the analogue of "Nachtstellung"). This author shows that if leaves of mosses and fern prothallia be brought from darkness into direct sunlight, no change in the position of their chlorophyll ensues, but that, after insolation, removal to the dark causes the grains to shift, to a greater or less extent, from Profilstellung into Flächenstellung. The chief point brought out by Stahl, however, is the one so well known from the reproduction of the figures in Sachs's and Pfeffer's works on Vegetable Physiology, viz. the behaviour of the chlorophyll of *Oxalis Acetosella* * leaves set in direct sunlight, under which circumstances the grains of the two lower layers of mesophyll cells first pass into Profilstellung and afterwards mass in the cells' corners, just as Borodin showed to be the case with *Lemna trisulca* &c. Stahl compares these phenomena with the movements of zoospores and Desmids †; his memoir also deals with several allied subjects which have no bearing upon the present paper.

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* "Beob. an. d. Prothallium d. Farrnkräuter."

† Ann. d. Sc. Nat. Bot. 4me série, tome vii. (1857).

‡ Bull. Acad. d. Sc. de St. Pétersbourg, 1867; reproduced in Pringsheim's Jahrb. f. wiss. Bot. Band vi., and translated in Ann. Sc. Nat. 5me série, tome vii.

§ Bull. Acad. d. Sc. de St. Pétersbourg, 1868 and 1869 (xii. and xiii.).

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* Pringsheim's Jahrb. f. wiss. Bot. Band viii. See also Bot. Zeitung, 1871. Prillieux had in 1870 (Comptes Rendus, tome lxx. p. 46) written a short account of the alterations in position undergone by the chlorophyll of *Funaria hygrometrica*, which, however, had previously been recorded by Borodin.

† Comptes Rendus, tome lxxviii.

‡ Bot. Zeitung, 1877.

§ Bot. Zeitung, 1880. Movement of the chlorophyll plate was first discovered by Wittrock (K. Svenska Vet.-Akad. Handlingar, Band v. 1878), who did not, however, suspect the agency of light.

The terminology adopted in the following pages is that of Frank, as being in best accord with the genius of our language. By the word "Epistrophe," however, I wish to be understood as implying the arrangement of the chlorophyll grains upon those walls which are at right angles to the plane of incident light; by "Apostrophe" the setting of the grains upon walls parallel to that plane. Moreover, it has been explained that apostrophe is caused by absence as well as by excess of light, and I shall show that it may sometimes be induced in poor grades of illumination; when occurring in the dark or in feeble light it is proposed to qualify the apostrophe as "negative," while "positive" apostrophe will express that the re-arrangement is the result of exposure to high illumination. To the whole phenomenon the term "photolysis" may perhaps be deemed suitable.

Are the grains drawn passively along with the streaming plasma, or have they the faculty of independent motion? is a question which has often been asked. It was answered years ago and repeatedly since in the former sense by Sachs ‡, and Frank § was strongly of the same opinion, in which Pfeffer * has also acquiesced. On the other hand, Prillieux † looks upon the movement as resulting from the attraction of one grain upon another, and of the cell-wall upon the grains, a curious notion which does not appear to have been shared by any other author. Velten ‡, while allowing the great importance of the protoplasmic stream in effecting transference of the chlorophyll, considered that the grains have some power of moving independentlyof the protoplasm. This opinion he arrived at from observing motion round their own axis of the grains of two species of *Chara*; but it seems almost impossible to decide that the protoplasm, in which the chlorophyll lies embedded, is not the agent whereby this movement is caused. Stahl § leaves the question unanswered, although he seems inclined to lean towards Velten's view, on account of the dependence, as respects size and form, of chlorophyll grains upon illumination.

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* Stahl also saw the same thing in many other types.

† Strasburger had previously done this in his memoir on zoospores in the 'Jenaische Zeitschrift' for 1878.

‡ 'Lehrbuch' and No. xxxv. of the 'Vorlesungen.'

§ Pringsheim's Jahrb. f. wiss. Bot. viii. pp. 234 and 282.

The reasons which have led me to declare in favour of Sachs's theory are the following:—

(i.) When photolysis is rapid (as *e. g.* in the cells of insolated *Elodea* leaves before rotation sets in) it is easy to see that the velocity of the chlorophyll grains is not greater than that of the granules swimming passively in the protoplasm.

(ii.) If *Elodea* leaves mounted in water and placed under the microscope on a warm summer day be exposed to strong illumination, the image of the sun being received upon the mirror, after two or three minutes the chlorophyll grains will be found in rapid motion, either in groups or singly upon the superficial or lateral walls. The groups swim in streams of protoplasm, the single grains run along fine threads of the same substance. Now it sometimes happens that, in consequence of the protoplasm streaming in opposite directions in the same thread, pairs of grains approach and clash, one of them turning by this means upon its edge and being thus enabled to pass its fellow. When the grains clash, a large part of their momentum must disappear; and if they were not passively drifting along, some appreciable slowing of their speed should be observed, because time would be required for the regeneration of that part of the lost momentum due to their own proper motion. But such retardation does not occur, for almost immediately after impact the journey is resumed at its former rate.

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* 'Pflanzenphysiologie,' ii. p. 397.

† Comptes Rendus, 1874, p. 752.

‡ Oesterr. bot. Zeitschr. 1876, no. 3.

§ Bot. Zeitung, 1880, p. 352. Curiously enough, all authors state that Stahl decides in favour of the passivity doctrine. He does nothing of the kind. His words are:—"Die Frage, ob die Körner sich bei diesen Vorgängen ganz und gar passiv verhalten oder sich in irgend einer Weise bei den Bewegungen den Lichtreize gegenüber thätig erweisen dürfte wohl kaum mit Sicherheit zu entscheiden sein. Die letztere Annahme gewinnt allerdings einige Wahrscheinlichkeit bei Erwägung der später zu besprechenden Gestaltsveränderungen von Chlorophyllkörnern, welche in manchen Fällen ziemlich rasch auf den Lichtreiz erfolgen."

(iii.) If light acts directly upon the grains it might be expected that they would sometimes spontaneously turn upon their own axis. I have failed to detect any instance of this movement which was not referable to some external cause.

Is the Movement transmissible?

A question of some interest is broached when it is asked whether, in view of Strasburger's theory of the universal continuity of protoplasm* and the undoubted fact that effects ascribed to the action of light are capable of transmission from one part of a plant to another †, the slow movements of protoplasm which cause the chlorophyll grains to change their position are also themselves transmissible. In order to answer this question, the following experiments were made.

Leaves of *Funaria hygrometrica* which had remained four days in darkness were placed in a shallow gutta-percha dissecting-tray half-filled with water; to the bottom of the tray was closely pinned a piece of cardboard, in such a way that while completely covering some of the leaves, others were left half exposed, the latter being retained in position by means of a small pin passed through their apex. Examined after three hours' exposure to good diffused light, the chlorophyll of the covered leaves being in apostrophe, that of the others was in apostrophe where covered, in epistrophe where uncovered, with a sharp line of demarcation between epistrophe and apostrophe.

In order to avoid any error which might have arisen from insufficiency of time, the experiment was repeated with leaves set in darkness overnight, allowing six hours instead of three for transmission to declare itself, but the result was precisely as before; and as trials made with *Lemna trisulca* under similar conditions had a like issue, one is bound to conclude that the movement is not transmissible. Moreover, from an inspection of the microscopical appearances shown by the well-known "Schattenbilder" of Sachs*, beautifully illustrated in Borodin's second memoir, the same conclusion is reached in respect of the higher plants.

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* *Vide* 'Bau und Wachsthum,' the section headed "Die Wegsamkeit der Zellhäute" (p. 246).

† As for instance in "sensitive" plants.

The Movements of Chlorophyll Grains in the Dark.

The observations of Famintzin, Frank, Stahl, &c. upon this subject have before been alluded to. The chief results obtained by them may be thus recapitulated:—

(i.) The chlorophyll of *Funaria* passes into apostrophe after some hours' exposure to darkness (exceptionally one hour, Borodin).

(ii.) Apostrophe is assumed by darkling plants of *Elodea* and *Vallisneria* very slowly, not being quite complete even in ten weeks (Frank); and in this they are imitated by fern-prothallia and most Musci and Hepaticæ.

(iii.) The grains of *Lemna trisulca* are, after twenty-four hours in the dark, nearly all collected upon the side-walls in the thin marginal portion of the leaf, or upon these and the inner wall in the thick central part; those of *Stellaria media* leaves are after the above period found upon the side-walls.

(iv.) If *Funaria*-leaves be brought from darkness into direct sunlight, no change in the position of the chlorophyll results; but if prothallia with grains in apostrophe be removed from sunlight to darkness, epistrophe is partially assumed.

It is a matter for surprise that, with the exception of some experiments on succulent plants and of Borodin's on *Stellaria media*, the behaviour in darkness of the chlorophyll of the higher aerophytes has never been recorded; and this is the more remarkable because, if care be taken in the selection of types, no difficulty worth mention blocks the way. In prosecuting his discoveries on the movement of the grains in sunlight, Stahl made chief use of *Oxalis Acetosella* leaflets which he, after insolation, discoloured and rendered partially transparent by the action of alcohol. For the following experiments it was deemed advisable, though not absolutely necessary, to choose as types the more transparent plants or parts of plants; by this means the position of the grains could be readily seen without the use of any reagent by simply focusing through the overlying epidermis, the air having been previously removed from the preparation by gentle pressure upon the cover-slip *.

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* Ber. d. math.-phys. Classe &c. 1859, and No. xxxv. of the "Vorlesungen."

The negative apostrophe of angiospermous chlorophyll may be well studied in seedling and adult plants of *Eschscholtzia californica.* If one of these be placed in darkness overnight, on cutting off a leaf-lobe in the morning and mounting it in water lower side up, by focusing through the epidermis it can easily be seen that the chlorophyll of the lower layer of mesophyll-cells which had, on the previous day, been uniformly or nearly uniformly distributed upon the walls lying, in the rough sense, in the plane of the leaf (Pl. VII. fig. 1), is now collected in dense masses in the corners of the cells, occupying exactly the position assumed after the prolonged action of sunlight (fig. 2). So closely are the grains packed that, but for their colour, the masses might be mistaken for local thickenings of the wall, the fact of their being composed of a number of similar small bodies being evident only upon occasion. It would appear that the *whole* night is not required for these grains to apostrophize; from the list drawn up on p. 234 it will be seen that although apostrophe takes more than six hours it is completed in much less than eighteen, by which time the grains have become *massed*, massing being always the result of *prolonged* exposure either to sunlight or to darkness.

Other sun-loving aerophytes were subjected to the same treatment with the same result, except that the massing of the grains usually makes a more tardy appearance. In the stellate mesophyll-cells on either side of the midrib of the involucral scales of the garden Chrysanthemum, as in the stipules of *Vicia Faba*, massing has commenced and may be well established after twenty-four hours' darkness; double that time was found requisite for the mesophyll of the primordial leaves of *Nigella damascena*, while it was only after a week in the dark that the mesophyll of *Centranthus ruber* and the cells of the small outer involucral scales of *Senecio vulgaris* had their grains in massed apostrophe, although in all these cases simple negative apostrophe is (as the table on p. 234 shows) induced as readily as in *Eschscholtzia* itself. But when we come to study shade-loving types, we see a great difference. If *Oxalis Acetosella* be set in the dark, the mesophyll of its leaflets may be examined day by day without detection of any difference in the relative position of the chlorophyll-grains in the lowest of the three layers; after ten days, however, apostrophe has decidedly set in (Pl. VII. fig. 3), but whether massing ensues upon further exposure to darkness is uncertain, all that can here be said is that after four more days it has not begun. In the same way, the cells immediately abutting on the lower epidermal layer of young autumnal leaves of *Saxifraga granulata* show only faint signs of apostrophized chlorophyll after a week's confinement in the dark, and even after three weeks apostrophe is very incomplete; and although it seems to be entirely brought about in the mesophyll of *Pteris cretica* kept in the dark for four weeks, yet even this long period is insufficient for *Pteris serrulata*. This is much the same state of things that earlier observers have found to occur in prothallia &c. and in *Elodea* and *Vallisneria*. Frank's statement that apostrophe is not induced in the two last within ten weeks I can well believe, my own darkling plants showing only partially apostrophized chlorophyll after six weeks' withholding of light, by which time they were so debilitated that it was thought unnecessary to continue the experiment. Moreover, negative apostrophe is very slowly brought about with *Callitriche verna*, uninjured parts of the leaves of which have their grains not quite all in apostrophe after three weeks' darkness; and in *Lemna trisulca*, although apparently somewhat different from other aquatic plants, in that apostrophe is nearly perfect in its cells within a few hours, yet in all my experiments a few of the grains in the marginal cells remained in epistrophe and had not all moved on to the side-walls even after three weeks. The grains of a debilitated specimen of *Utricularia vulgaris*, the only one available, had not all of them passed on to the side-walls after two days in the dark: those of *Ceratophyllum demersum* likewise move very slowly into negative apostrophe; indeed, I have seen darkling plants of this species showing scarcely any sign of a fortnight's incarceration.

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* Removal of the air with the air-pump has been recommended, but this is quite unnecessary.

And as in shade-loving Cryptogams, like fern-prothallia and most Musci and Hepaticæ, negative epistrophe is very slowly induced, so, too, aquatic Cryptogams would seem to offer the same peculiarity if *Hypnum fluitans* be not an exception, the grains of the wider cells at the base of the leaves of this type not having been completely apostrophized after a month in darkness.

Before leaving this subject it may be mentioned that it is not always necessary to withdraw light altogether in order to induce negative apostrophe; with ordinary aerophytes this will result in *low light*, under which circumstances apostrophe is set up in periods approximately, though not quite, equal to those necessary for its production in darkness. I have witnessed this with ***Funaria hygrometrica***, seedlings of ***Eschscholtzia californica***, and involucral scales of garden Chrysanthemum and *Senecio vulgaris*, as well as leaf-sheaths of *Poa annua*; and as no exception has been discovered, this is probably a rule of universal application to plants of this kind.

Massing of the grains on prolonged withdrawal of light has already been mentioned as occurring in ordinary aerophytes. Even ***Funaria hygrometrica*** may sometimes, though very rarely, show it, the grains collecting usually upon the fore or the aft wall, or both. Fig. 4 (Pl. VII.) is taken from a plant kept a fortnight *in very low light*. In the leaf-sheaths of *Poa annua* kept in darkness for twenty-four hours, fore-and-aft massing may sometimes be observed; but when it does occur, massing is usually in the form represented in figs. 5 *a* and *b*, the nucleus being the focus round which most of the grains are distributed. Nor do aquatic types yield negative results, for if *Lemna trisulca* plants be examined after about a month's incarceration, the grains, greatly reduced in size and discoloured, of the marginal cells will be found to a large extent collected in little heaps in their angles. Moreover, if small pieces containing about half-a-dozen internodes of ***Elodea*** be set in darkness, the greater number of the grains may after some days be disposed upon the walls, either in fore-and-aft arrangement (fig. 6 *a*), in the corners (6 *b*), or to a greater or less extent upon the nucleus (6 *c*). So, too, with *Callitriche verna*: fig. 7 *a* shows most of the grains of a cell in simple apostrophe after ten days' darkness; figs. 7 *b* and *c* represent the effects of ten days in the dark upon cells nearer the apex of the leaf (where apostrophe more quickly betrays itself), in which the grains are reduced in size and have massed, this time not in the angles, and not always upon one of the lateral walls*. It would seem, then, that massing is of frequent occurrence, not only among aerophytes but also in aquatic types.

But this is not all. Numerous experiments, especially those of Stahl, have shown that the grains in the palisade tissue of the leaves of phanerogams are ordinarily very little movable on insolation. By exposure to darkness for a few days, the grains of either of the two rows of palisade-cells of *Eschscholtzia californica* seedlings will be found massed together so closely that, as in the mesophyll under similar circumstances, the masses appear, but for their colour, as local thickenings of the wall. Fig. 8 (Pl. VII.) represents in a bird's-eye view two palisade-cells with massed grains; and figs. 9 *a* and *b*, which are sectional views, show that the masses are collected in the narrowest parts of the cell, that is to say in fore-and-aft fashion. The difference between darkling and illuminated palisade-tissue is easily made out, since in the latter the grains are disposed uniformly round the circumference in bird's-eye view, whereas in the former this is not the case. Whether or no the palisade-tissue of other types shows the same peculiarity has not yet been determined.

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* In his second memoir Böhm notices massing of the chlorophyll of *Sedum spurium* in the dark.

If a plant with negatively apostrophized chlorophyll be removed to diffused daylight, the grains move into epistrophe after a period depending on the quality of the light and on the type used. Thus, three weeks' apostrophizing of *Elodea* was repaired by four days in diffused light; five hours' of *Stellaria media* mesophyll by three and a half hours; ten days' of *Oxalis Acetosella* by three days, and so on. These and similar cases are treated of under a subsequent head. (See the table on p. 234.)

Recovery from massed negative apostrophe is possible, provided that, in order to induce it, there be no necessity to keep a plant too long in darkness. As with massed positive apostrophe, so with negative; a longer time is needed to epistrophize the grains than if they started from simple apostrophe. But it may happen that, in order to cause massing, so long an exposure to the dark is essential, that recovery of the cell to its normal condition is impossible. I have seen this in the marginal cells of *Lemna trisulca*, with the exception of a few near the base, in which recovery took place. It must, however, be mentioned that *L. trisulca* is soon weakened by confinement in a close room, even under favourable conditions of illumination; it is therefore possible that the failure to recover is not entirely due to withdrawal of light.

A still further change in the disposition of chlorophyll sometimes results from prolonged withdrawal of light. Thus the cells of *Funaria hygrometrica* plants, set in the dark for three weeks, were found to be of one of the following descriptions:—

(i.) Quite dead and empty, except for a few spherical colourless particles.

(ii.) As (i.), but with a few small spherical red-brown bodies (degraded chlorophyll grains) oscillating in the cell.

(iii.) With a number of red-brown bodies massed upon either of the free (superficial) walls; the bodies were usually in oscillation.

(iv.) With brownish quiescent grains, much smaller than those of healthy cells, lying either on the lateral walls for the most part, or in larger proportion or almost entirely on the free (superficial) walls, or fairly evenly distributed on all the walls.

(v.) With the characters of (iii.) and (iv.) combined.

(vi.) With grains still green, and appearing but little the worse for their imprisonment, ranged either exclusively on the side or on the free walls (in the latter case recalling epistrophe to the mind), or disposed impartially on all the walls: these grains did not oscillate, nor were they collected into masses.

The large cell crowning each paraphysis has massed grains after three weeks' confinement in the dark. The masses, which are collected at two or three points on the lateral wall, are formed of small red-brown bodies closely resembling those of the leaves.

It appears, then, that the negatively apostrophized chlorophyll of *Funaria* tends, upon protracted withholding of light, to move back again towards epistrophe, which it may sometimes almost or quite reach. Fig. 4 (Pl. VII.) shows the movement in progress, combined with an evident tendency of the grains to collect in one part (here the proximal end) of the cell: this figure was drawn from a plant kept in very low light (insufficient to epistrophize already apostrophized chlorophyll) for a fortnight, so that in order to bring about this rearrangement (which may be called "negative epistrophe," or, perhaps, more correctly "astrophe") total exclusion of light is not necessary.

The same movement upon prolonged exposure to darkness was also seen in a few of the proximal marginal cells of *Lemna trisulca* after a month's imprisonment, and figs. *7 b* and *c* (especially the former) show it in *Callitriche verna*. Whether the massing round and near the nucleus in *Poa annua*, previously described, and in the epidermal cells of *Pteris serrulata* (fig. 10) are instances of it is doubtful, since its essential feature resides in the fact of its appearing after apostrophe.

It will be remembered that it has been discovered that if prothallia be set in darkness when their grains are in apostrophe, epistrophe is partially assumed, negative apostrophe not setting in until some time afterwards. This is by no means an exceptional case. *Elodea, Vallisneria, Ceratophyllum, Callitriche,* and, to a considerable extent, *Lemna trisulca* show the same peculiarity. Thus, positively apostrophized *Elodea*-grains move into epistrophe within forty-eight hours of removal to the dark, and it is now impossible to detect any difference in the distribution of darkling and illuminated grains; and the same may be said, except for variations as to time, for all the rest. Moreover *Pteris cretica* and *P. serrulata, Oxalis Acetosella,* and *Saxifraga granulata* resemble the above-mentioned aquatic types. On the other hand, the positively apostrophized chlorophyll of *Funaria hygrometrica* remains in apostrophe on exposure to darkness, as does that of *Urtica urens* stipules, and of *Centranthus ruber* and *Eschscholtzia californica* mesophyll.

The results obtained under this head may thus be summed up :—

(i.) The epistrophized grains of sun-loving plants (both Phanerogams and, so far as experiment has yet gone, Cryptogams also) are negatively apostrophized after a few hours in darkness.

(ii.) Negative apostrophe is very slow in making its appearance in aquatic types (*Lemna trisulca* being a partial exception), and likewise in shade-lovers, such as fern-prothallia, *Pteris, Oxalis,* and *Saxifraga granulata**.

(iii.) Negative apostrophe can be induced in sun-loving plants in low light.

(iv.) The effect of continued darkness upon grains already apostrophized is to drive them into masses in the corners, or, more rarely, upon the side-walls of the cell. This is much more quickly brought about in sun-loving than in aquatic types. Moreover it may also occur in palisade-tissue.

(v.) Still longer exposure to darkness may cause many if not all of the grains to come out on to the free (superficial) walls, where they may remain distributed with fair uniformity or collected into larger or smaller masses.

(vi.) Positively apostrophized grains of sun-lovers remain in apostrophe on removal to the dark; those of aquatics and shade-lovers are to a greater or less extent epistrophised by this treatment.

The Epistrophic Interval.

If, on a dull day in late summer or autumn, a leaf be taken from each of the following types, growing in low diffused light, viz. *Funaria hygrometrica*, *Callitriche verna*, *Elodea canadensis*, and *Lemna trisulca*, and mounted in water on glass slides, after remaining under uniform conditions of illumination close to the window of a room for two hours or thereabout, it *may* happen, provided that the light be of the exact quality required, that the chlorophyll of *Callitriche* will be in epistrophe, while in the other three it will be in apostrophe*. Should now the weather clear up, so that the leaves are for some time exposed to good diffused light, the grains of *Lemna* will remain in apostrophe or show more or less tendency towards massing in the corners of their cells; those of *Elodea* will rotate round the cell-periphery; in *Callitriche* they will be found in apostrophe; while epistrophe will be established in *Funaria*. To superficial observation the simultaneous apostrophe of the chlorophyll of *Funaria* and of *Elodea* would seem due to the same cause; the remarkable fact of its dependence in the former plant on deficiency, in the latter on excess of light, would, one might safely say, never be even suspected.

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* With respect to this last see p. 219.

It is therefore plain that if a graphic representation, as extension in space, of the whole range of possible grades of illumination from darkness to direct sunlight be drawn upon a uniformly reduced scale, it will be found that the portion of the scale representing the various intensities of illumination sufficient to bring out negatively apostrophized grains into epistrophe and insufficient to drive epistrophized grains into apostrophe will depend very much, in respect of extent and position, upon the plant which is made the subject of experiment. To this portion of the scale, comprising all epistrophizing grades of illumination, it is proposed to apply the term "epistrophic interval"; for the whole scale the word "photrum" may, perhaps, be allowed as at once simple and convenient. It goes without saying, that great difficulties stand in the way of the proper construction of the photrum. In the after-mentioned experiments the photrum was twelve feet long; the end nearest to sunlight (which it is proposed to call the "positive" end) was close to the only window of a room from which the sun's direct beams were excluded by means of a venetian blind, except for a narrow space below. Under these circumstances there can be no doubt that the photrum was curtailed at the positive end. Then with regard to the end abutting on darkness (hereafter referred to as the "negative" end), the diminishing intensities of light were obtained by the use of screens, carefully adjusted it is true, yet necessarily leaving much to be desired on the score of accuracy: here, also, it is probable that the photrum was too much shortened. Another objection is that the quality of sunlight is very variable, depending, as it does, upon the amount of condensed and aqueous vapour in the atmosphere; and this variation must obviously extend over the whole photrum. Results obtained by this method are therefore strictly comparable only in respect of experiments made on the same day and between the same hours. The foregoing considerations render necessary the proviso that the statements which immediately follow represent the facts merely in a rough-and-ready way, which nevertheless will, perhaps, be deemed preferable to a simple unillustrated account.

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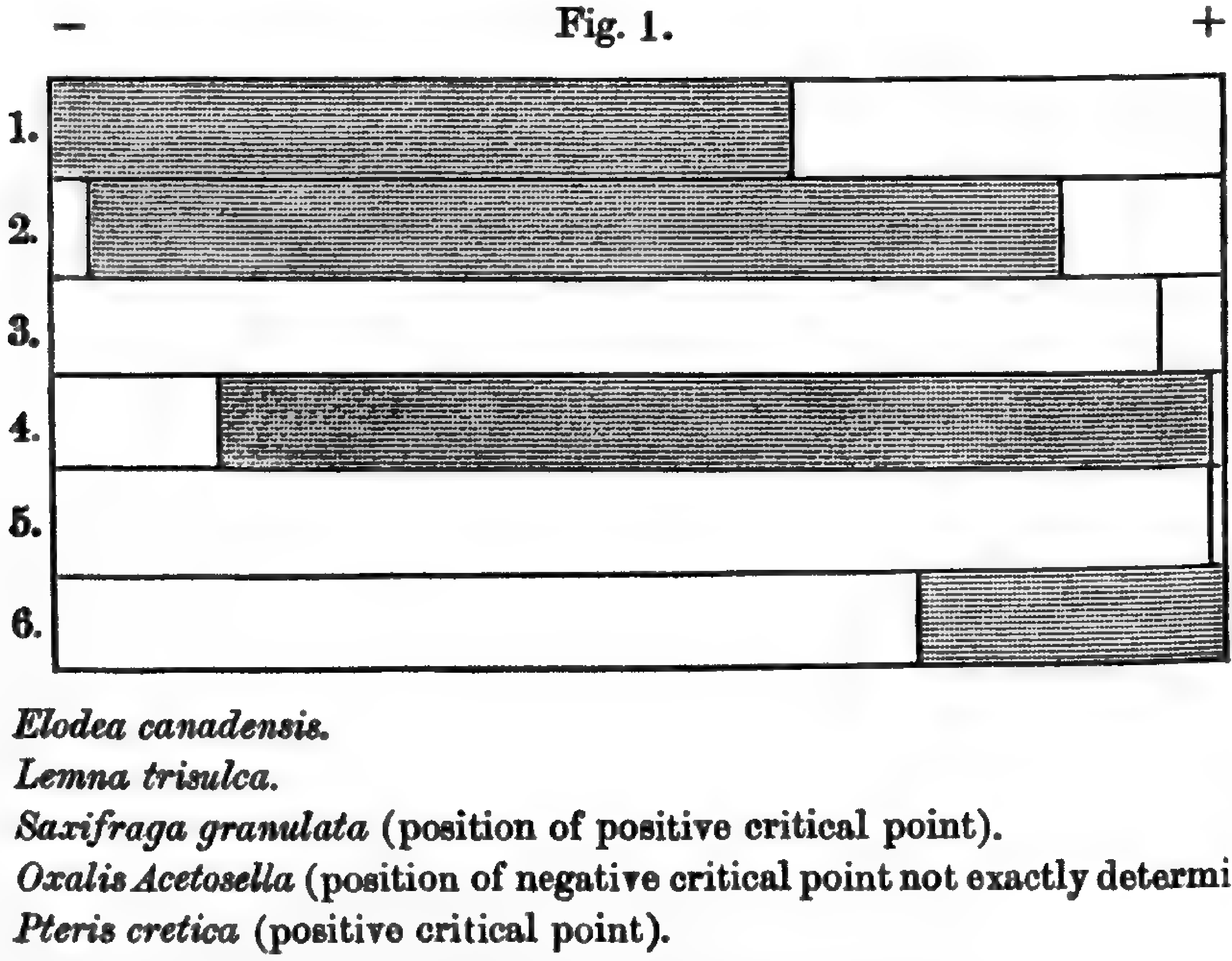
* In some of the *Elodea*-cells a few of the grains may be in epistrophe, either solitary or grouped. This is exceptional if the light be all that is required for the success of the experiment.

Fig. 1.



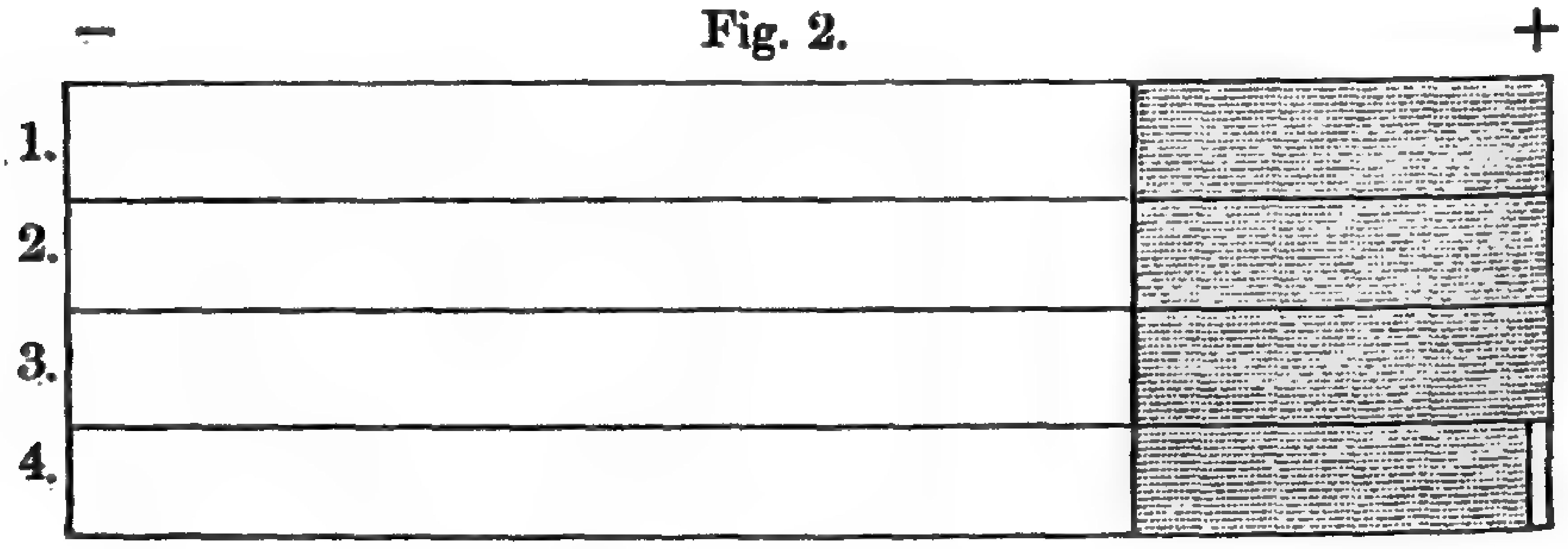
1. *Elodea canadensis.*
2. *Lemna trisulca.*
3. *Saxifraga granulata* (position of positive critical point).
4. *Oxalis Acetosella* (position of negative critical point not exactly determined).
5. *Pteris cretica* (positive critical point).
6. Scale of garden Chrysanthemum (*Pyrethrum sinense*).

(In this and the following diagrams the epistrophic interval is shaded.)

The first diagram (fig. 1) was constructed on a fine day in November. In this, as in the following experiments, the photrum having been duly adjusted, the leaves to be experimented with were rapidly cut off and mounted in water upon ordinary glass slides, each leaf being covered with a piece of thick glass to keep it extended in the plane of the slide. The slides were then set out in the photrum at short intervals. After remaining in these positions for three hours, during which time the sun had been shining brightly, care having been taken to keep the specimens well moistened with cold water, the slides were successively inspected, commencing at the positive end, and as soon as a leaf was found with grains showing no signs of positive apostrophe, the distance between the place occupied by it and the positive end of the photrum was measured. The length of the photrum on the reduced scheme being three inches, it only remained to divide the above distance by forty-eight and mark off the quotient on the diagram. The point at the extreme right end of the epistrophic interval it is proposed to call the "positive critical point," because the light at this point in the photrum is not quite strong enough to apostrophize the chlorophyll. It sometimes happened that, while one specimen showed signs of apostrophe, the grains of its successor were wholly in epistrophe, in which event the critical point was fixed halfway between the two; and no appreciable error could ensue from this, seeing that if error there were, the scale would represent it diminished forty-eight times.

The determination of the point at which epistrophe passes into negative apostrophe (which may be named the "negative critical point") is a much more difficult matter. In the case of Chrysanthemum, it was found by placing in various positions in the photrum scales from a cut shoot set overnight in darkness. It has already been seen that the grains of Chrysanthemum-scales move from negative apostrophe into epistrophe in from three to four hours; consequently in three hours the movement will be nearly completed. Acting upon this idea, the specimens were examined after the above interval, beginning at the extreme right end, and as soon as one was reached which had none of its grains in epistrophe, the position occupied by it was noted as the negative critical point required. This method would have been applicable to *Lemna trisulca*, for we know that it can recover in thirty-five minutes from the large amount of apostrophe induced by six and a half hours' withdrawal of light; only here, in order to avoid ambiguity, it would have been necessary to decide the negative critical point from the failure, after the three hours, of *any* of the grains to pass into epistrophe. Instead of this, the negative critical point of *L. trisulca* has been fixed with, it is trusted, fair accuracy by studying the behaviour of specimens kept for several days in light of different intensities, each intensity estimated, as cautiously as possible, in terms of the photrum. But far different is the case with ordinary aquatic and shade-loving plants, the grains of which require several days or even weeks to pass into negative apostrophe; the only way to determine the negative critical point of these is to keep them for some time in very low light. Treated in this way, it was found that healthy *Elodea*-plants, exposed to the lowest illumination for a fortnight, showed no signs of apostrophe; it is therefore safe to affirm that the epistrophic interval of this type abuts on darkness. It must not be forgotten that large approaches to apostrophe are observed under the above conditions if the specimens be old and weak or fragmented. Want of time and paucity of material have prevented my fully dealing with the other types of this set.

Fig. 2.



1. *Funaria hygrometrica* (leaves).
2. Garden Chrysanthemum (involucral scales).
3. *Urtica urens* (stipules).
4. *Poa annua* (leaf-sheaths).

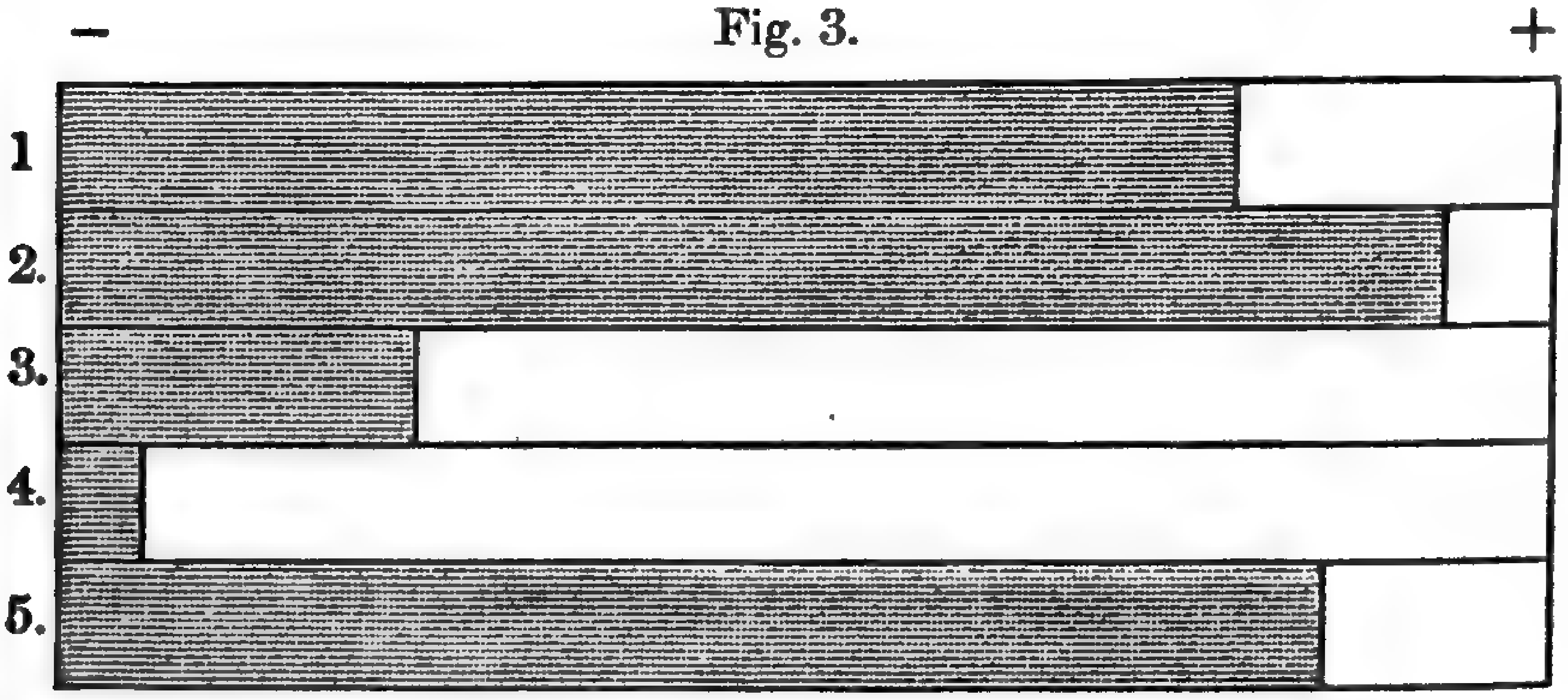
The next diagram (fig. 2) shows the epistrophic interval of four land-plants, viz. *Funaria hygrometrica* (leaves), *Pyrethrum sinense* (involucral scales), *Urtica urens* (stipules), and *Poa annua* (leaf-sheaths). The positive critical point, which in the first three of these extends to the right-hand extremity of the photrum, was determined upon two hours' exposure under conditions similar to those before mentioned; the negative critical point was found from specimens set in darkness overnight, and laid out in various positions in the photrum for between three and four hours (the time required by the grains to move into epistrophe) immediately after removal from the dark. The negative critical point of the *Poa*-grains occupied the same position as that of the others, but at the positive end the epistrophic interval was somewhat curtailed.

One word of caution is necessary here. The above-drawn epistrophic intervals were found in November and December last; it is probable that some difference in their length and position will be noted if experiments be conducted in summer. I am the more inclined to think this from observing during the past summer that it was not necessary to put the leaves of *Funaria hygrometrica* into actual sunlight to apostrophize the grains; if the sky was clear the change took place in the shade close to the rays of sunlight streaming into the room.

Hitherto it has seemed, in the absence of any statement to the contrary, that the protoplasm of all cells of a plant is affected to the same extent by light, the grains epistrophizing from negative apostrophe and positively apostrophizing from epistrophe at certain fixed grades of illumination. But this is by no means always the case. If an *Elodea*-leaf be mounted in water and exposed on a glass slide to rather poor diffused light, after a little time all or most of the chlorophyll grains in the larger cells (those placed upon the leaf's upper face) will be found upon the side-walls; while in the lower layer of smaller cells, provided that the illumination be not too high, only a slight (if any) tendency to apostrophe will show itself. The effect of the inertia of the grains upon their transference in space is alluded to on p. 224: with reference to this point, it may be pointed out that the grains of the lower are considerably smaller than those of the upper cell-layer, a circumstance favourable to rapidity of movement; but it must not be forgotten that the lower cells, being smaller than their overlying neighbours, contain less protoplasm, and there is every reasan to believe that the gain on the score of inertia is approximately balanced by the loss in respect of protoplasmic momentum, and, as a corollary, that the difference in the epistrophic interval of the upper and lower cells is, to a large extent, the result of a difference in the response to the stimulus exerted by light upon their protoplasm; and this view seems still more reasonable when it is remembered that resistance to movement cannot be greater in the lower than it is in the upper cells, provided that the form of the cells and the relation between their size and the size and number of their grains be approximately the same; and this seems to be the case.

Diagram 3 is a graphic representation of these facts. Immediately below the epistrophic interval of the healthy lower cells of a leaf (which, it will be observed, is developed much further to the right than the upper cells' interval) is drawn the greatly curtailed interval of certain upper-layer cells in the neighbourhood of the small discoloured spots so frequently to be found in *Elodea*-leaves; this curtailment shows, if the argument just concluded be sound, that injury to the leaf lowers in a marked degree the capacity of the protoplasm of still apparently healthy cells in the neighbourhood of the wound to withstand the motile effects of light. Underneath this is shown the interval of the upper, and below that of the lower cell-layer of small leaves growing upon plants which, after having lain for some days in a 2-per-cent. solution of ferrous sulphate, had, after washing and transference to water, been placed for several weeks in very poor light, and had suffered etiolation in consequence. Between these two there is an extraordinary difference, for while the protoplasm of the lower layer shows not much more sensitiveness to light than is usually met with in healthy green leaves, the plant must be kept within a very short range of the lowest illuminations if the grains of the upper-layer cells are not to be driven into apostrophe. It might be thought that the greater sensitiveness of the latter cells' protoplasm is due to its more exposed position with respect to the impact of light; this is, however, a mistake; side by side with every leaf used in the construction of the intervals of the present diagram was placed a similar leaf taken from the same whorl, and

Fig. 3.



1. *Elodea canadensis*, upper cell-layer of green leaf.
2. Ditto, lower cell-layer of green leaf.
3. Ditto, upper cells of green leaf near discoloured spots.
4. Ditto, upper cell-layer of the leaf of an etiolated plant growing for some time in very low light in confined space at the back of a room.
5. Ditto, lower cell-layer of etiolated plant.

mounted lower side uppermost. In no case was the sensitiveness of the protoplasm affected by the position, as regards the zenith, occupied by its containing cells.

This chapter may be brought to a conclusion with the mention of the following points:—

(1) The length of a plant's epistrophic interval depending upon the quality of its protoplasm, the reason for the caution expressed in the opening sentence is apparent. In order that the experiment there spoken of may succeed, it is necessary not only that the light be of precisely the proper quality, but the protoplasm of all the plants must either be perfectly healthy, or corresponding inroads into its health must have been made in all cases.

(2) It would appear that if an epistrophic interval do not reach far to the right, it will extend some (perhaps all the) way upon the left side of the photrum; and this seems to be a general rule. *Overlapping* intervals do occur, however; one such was found in the case of a moss growing with *Funaria hygrometrica*, the chlorophyll of which required better sunlight to positively, and feebler light to negatively apostrophize it than did the *Funaria*.

(3) The epistrophic interval of all aquatics is developed far more upon the left than upon the right side of the photrum; that of sun-loving aerophytes is restricted to the right side, while shaded aerophytes have an interval intermediate in position. This generalization applies to all types irrespective of their morphological relationship.

(4) Besides quality of protoplasm and habitat, it may, perhaps, turn out that the interval is, at least to some extent, determined by the season in which a plant grows. This is the only way in which the behaviour of *Saxifraga granulata* can be accounted for; the rosulate leaves of this type may, perhaps, to some extent be protected from the sun by overshadowing grass-blades &c.; but a more reasonable view of its resemblance to shade-lovers is that, although exposed to sunlight, the office of the leaves has been performed before that period of the year arrives when light is of the highest intensity. Whether this doctrine is of wider application has not yet been determined.

Lastly, as extreme cases of difference in respect of the motile agency of light on the protoplasm of the same individual, the *Characeæ* may be referred to, the divergence here applying not to different parts of the plant, nor to abnormal protoplasmic conditions, but to the normal state of every cell. The parietal zone consists of protoplasm toned so highly to light that the chlorophyll embedded in it does not manifest, even in direct sunlight*, the slight movements of apostrophe and epistrophe; whereas the inner zone exceeds the protoplasm of *Elodea* in sensitiveness to light as much as the latter does the protoplasm of ordinary types. This coexistence in the same cell of the extremes of mobility and of impassiveness is, despite its familiarity, a highly remarkable circumstance.

On the Nature of the Movement of Chlorophyll Grains.

Why do the chlorophyll grains move into positive apostrophe? Can it be, as Böhm† thinks, to avoid the destructive effects of light? If so, it is very remarkable that the position of the positive critical point should be so variable in the photrum, not only as respects different types, but also different individuals of the same species and different parts of the same individual. Is it possible to believe that the chlorophyll of, for instance, the lower cell-layer of *Elodea*-leaves differs so much in constitution from that of the upper cells that it can without injury suffer exposure to light of intensity sufficient to destroy the upper chlorophyll? This consideration seems to warrant an emphatic negative to Böhm's theory, quite apart from the objection urged against it by Stahl‡, that before it can be said to be safely grounded, the onus is upon its upholder of proving that the grains are destroyed by sunlight if their apostrophization be prevented§. Stahl‖ has himself fathered a hypothesis to the effect that the aim of apostrophization of chlorophyll in sunlight is to prevent accumulation, to an injurious extent, of the products of assimilation. Apart from the charge of embodying a discredited form of teleology

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* Pringsheim (Ueber Lichtwirkung und Chlorophyllfunction in der Pflanze, p. 333) found that in concentrated sunlight movements are excited in the parietal protoplasm, as is evidenced by the grains shifting their position. Velten has recorded very slight movement in the parietal protoplasm (Oesterr. bot. Zeitsch. 1876, no. 3).

† This is stated on Stahl's authority (Bot. Zeitung, 1880, p. 381). I have failed to find the reference in either of Böhm's memoirs.

‡ Bot. Zeitung, 1880, p. 381.

§ It is scarcely necessary to say that the behaviour of the grains in concentrated sunlight, as observed by Pringsheim, is not in point.

‖ Bot. Zeitung, 1880, p. 381.

(an objection applying equally to Böhm's view), this doctrine also gives no explanation of the dependence of the positive critical point upon species, individual, and cell. Can it be that this supposed injurious accumulation commences in aquatic plants at grades of illumination far lower than those necessary to produce the same effects in sun-loving types? If so, where are the experiments which render this doctrine probable? And if there are none (and I know of none), does not Stahl lay himself open to precisely the same objection which he finds to Böhm? Nor is this all. If the grains are apostrophized in order to prevent some supposed injury which it is in the capacity of light to inflict upon them, why do they assume precisely the same position in darkness, *i. e.* under circumstances rendering injury by light impossible? If Stahl's view be retained, we can only account for the facts of negative apostrophe by sinning against the Newtonian injunction with reference to the multiplication of causes. Before doing this, let us see whether there is not a simpler theory capable of accounting for the facts not only of positive but also of negative apostrophe.

It is admitted on all hands that the prime agent in the variations in position undergone by chlorophyll is the protoplasm of the cell, authors differing only as to whether this is the sole cause or whether the grains themselves be not to a slight extent contributory. For present purposes the latter question may be overlooked. It is therefore obvious that, when epistrophe sets in, the tendency of the protoplasm is to collect upon the superficial walls, the grains being carried out from the side-walls in consequence. But when, as the result of insolating leaves of *Funaria*, for instance, the grains move to the side-walls, this happens because a reverse condition is set up, the protoplasm now tending to move away to the least highly illuminated portions of the cell. The fundamental mistake made by Böhm and Stahl is in ignoring in their respective theories this attracting and repelling action of light upon protoplasm. The researches of Famintzin, Cohn, Schmidt, Stahl, and especially Strasburger have taught that light has great influence on the movements of zoospores. Strasburger*, it will be remembered, finds that zoospores whose movements are affected by light (called by him "phototactic") are either "aphotometric," that is move uniformly towards the source of illumination, or "photometric," inasmuch as light is approached or receded from according to its intensity. The phenomena of photolysis would seem to be explicable on the view that this phototactic quality of zoospores is a general property of cell-protoplasm. But besides zoospores, the Myxomycete plasmodium has been shown by Baranetzky * modifiable by light, since the pseudopodia, emitted on all sides in darkness and low light, are, when strongly illuminated, drawn in upon the more highly lighted, and developed upon the shaded side.

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* Jenaische Zeitschrift, 1878. The bibliography of the subject will be found there.

The doctrine advanced here is, that the movements of chlorophyll have no relation whatever to benefit or injury experienced by the grains, nor necessarily to the well-being of the protoplasm, but that just as in Strasburger's "Lichtstimmung" experiments, in which a zoospore moved towards or away from a certain degree of illumination, according as to whether it was of low or high grade, so in respect of any plant there are two points in the photrum—the positive and negative critical points—at one of which its protoplasm begins to be repelled from the superficial to the side wall, and at the other to be turned in the reverse direction; in short, it is submitted that all the phenomena are to be explained on the supposition that protoplasm is phototactic —negatively to light of high, and positively to light of medium intensity.

Before proceeding to dwell upon this theory in detail, it will be well to refer to another matter closely connected with it. Suppose that a *Funaria*-leaf, removed from darkness in which it has lain overnight, be set in good diffused light: the protoplasm tends to collect upon the surface-walls, and, in so doing, a strain is imposed upon its micellæ. If the leaf be now brought up into sunlight, an increased strain is experienced by the protoplasm as it makes for the side wall. Now the elastic recovery of solid bodies submitted to twists or strains depends upon, first, the amount, and, secondly, the duration of the disturbance; and I shall endeavour to show that the movements of protoplasm can best be explained on the supposition that it is affected by light just as a solid body is by a twist or strain. One of the most remarkable facts about the changes of position shown by chlorophyll is that negative apostrophe is so slow in establishing itself in the aquatic plant, while it is rapidly induced in ordinary aerophytes. It will be remembered that the positive critical point of aquatics is situated much further to the left of the photrum than is that of aerophytes. What does this mean? Obviously, that the protoplasm of the former is more sensitive to light, or, in other words, that light is capable of imposing a greater strain upon it. We should consequently expect that the protoplasm of aquatics would recover from the effects of the strain more slowly than that of aerophytes, or, to use the language of electricity as applied to the "residual charge" on a Leyden jar (a phenomenon now believed by electricians to be only another instance of elastic recovery), the "charge" of light would more readily "soak out" of the aerophytic than out of the aquatic protoplasm. It is submitted, then, that so long as a darkling plant has its grains in epistrophe, so long, even though it may have been imprisoned weeks or months, do the motile effects of moderate illumination upon its protoplasm remain manifest*. Moreover, the behaviour of the positively apostrophized grains of aquatics and aerophytes set in darkness is a pure enigma, unless viewed from some such standpoint as is here taken up. When a leaf of *Funaria* with positively apostrophized grains is deprived of light, no appreciable alteration in the position of the chlorophyll occurs, and apparently for the following reasons. Two actions are now in operation, viz. recovery of the protoplasm from the extra strain of apostrophization (this would of itself tend to epistrophize the grains), and the elimination of the disturbance induced by epistrophization (which would, if it acted alone, result in driving them on to the lateral walls). Although, as is shown in the table on p. 234, epistrophization from positive apostrophe takes less time than negative apostrophization from epistrophe, which would lead to the surmise that some tendency to epistrophe ought to be seen if the theory be sound, yet it must not be forgotten that signs of apostrophe soon manifest themselves in darkling *Funaria*-leaves, full apostrophe under exceptional conditions being established in the short space of one hour. It may therefore be safely assumed that soon after an insolated *Funaria*-leaf has been placed in darkness, there is set up in the protoplasm of its cells a tendency which, if unchecked, would cause accumulation of the protoplasm on the superficial walls, and consequent epistrophization of the chlorophyll. What are the forces conditioning the setting-in of this movement? Plainly, the momentum of the protoplasm diminished by the inertia of the grains; the retardation due to friction of, first the protoplasm against the wall, secondly the grains against the wall, thirdly the protoplasmic stream against the grains; and, lastly, the loss of momentum consequent upon impact of the grains upon their fellows. If, therefore, there come into play another force equal to the difference between the momentum capable of being accumulated in the protoplasm and the retarding forces, and acting in the same way as the latter, no epistrophization can take place. In the *Funaria*-leaf under notice this force is none other than the force by which negative apostrophe is brought about, and the considerations just cited account for the fact that, although the latter force comes more tardily into play than the epistrophizing force, the positively apostrophized grains of darkling *Funaria*-leaves do not pass into epistrophe. But in the cell of a darkling aquatic plant, with positively apostrophized chlorophyll, a very different state of things exists. Here light has imposed a greater strain upon the protoplasmic micellæ, and recovery should be more gradual. The first portion of the strain to begin to disappear will obviously be that by which positive apostrophization was caused: this would be the signal for epistrophization to commence and finally to prevail, it not having been checked or prevented by an opposing negatively apostrophizing force, because, as is shown by the table on p. 234, negative apostrophe, on account of the slow rate at which effects produced by light soak out of aquatic protoplasm, does not set in until some weeks after light has been withdrawn from aquatic types.

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* Mém. Soc. Hist. Nat. de Cherbourg, xix.

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* I hope upon a subsequent occasion to deal with the fructifying causation of light in a detailed manner. It must here suffice to mention Strasburger's discovery (Jenaische Zeitschr. 1878) that many phototactic zoospores for a short while continue to move, after a sudden change in the intensity of light, in the direction due to the former illumination: this phenomenon, closely similar to the slow soaking out of motile effects in darkness, is well reproduced in rotation.

If the present argument be sound, the time taken by protoplasm to recover from the effects of insolation should vary directly as the time of exposure. It may be stated as a general rule that this is undoubtedly the case. The easiest way of applying this time test is to experiment with plants whose grains have been driven, some into simple, some into massed apostrophe, epistrophization from the latter phase requiring much longer than from the former. I believe the statement is also true of simple apostrophe; but I am not in a position at present to give figures in elucidation of this point.

To proceed now with the phototactic theory of photolysis. It is known that protoplasm has a wonderful power of slowly adapting itself to the conditions under which it is placed. If, therefore, the movements, in virtue of which chlorophyll is epi- and apostrophized be protoplasmic alone, and without any *arrière pensée*, as it were, to chlorophyll itself, we should expect to find that the protoplasm of aquatic types would be toned to light of low intensity, because it is only under unusual conditions that these plants are exposed to highly-diffused illumination or direct sunlight. Upon the same grounds it might be anticipated that sun-loving types would have their grains in epistrophe in light of intensity sufficient to induce apostrophe in aquatics; in other words, the position of its epistrophic interval ought to depend upon a plant's habitat, so far as this is affected by illumination; and this it has already been shown is the case.

Secondly. The view that protoplasm is toned to a certain intensity of light is warranted by the fact that apostrophe of the grains in cells neighbouring on dead cells is more readily effected with light of good enough quality to cause apostrophe in healthy cells than it is in these latter, and can take place at grades of illumination insufficient to apostrophize the grains of healthy cells. Upon Böhm's theory, proximity to a dead cell must increase the sensitiveness of chorophyll to light; while supporters of Stahl would be forced to admit that the neighbourhood of dead cells is a region where assimilation is more active than ordinary. It is submitted that this alone drives Böhm's and Stahl's theories from the field, whereas the supposition that a dead or dying cell must exert a lowering influence upon the protoplasm of its neighbours, not only because its own protoplasm is in a morbid condition, but because all the protoplasts are placed in continuity*, is surely by no means an extravagant one. One might therefore, upon these grounds, predict that the epistrophic interval of the cells in question would not reach so far to the right as does that of healthy cells.

Thirdly. If the tone of the protoplasm with respect to light depends on its quality, it ought to be expected that the epistrophic interval of cells, the protoplasm of which is injured by any cause whatever, would be curtailed towards the right. Frank says that (positive) apostrophe is favoured by sectioning, by exposure to abnormal temperatures, by diminution beyond a certain limit of a plant's watery contents, and by withdrawal of oxygen from it, and by old age. Supporters either of Böhm's or of Stahl's theory are, upon each of these points, confronted with a difficulty precisely similar to that pointed out under the last head. Moreover Frank's list is not quite exhaustive, for poisoning is a ready means of inducing apostrophe. Why the grains of a plant treated with a 3-per-cent. solution of ferrous sulphate or ferric chloride should apostrophize at lower grades of illumination than another's not so acted on, is perfectly mysterious except upon the view that use of the poison has brought lowering of protoplasmic tone in its train; in none of Frank's cases is the mystery less, nor less completely solved by the same method of reasoning. Frank, indeed, goes to the length of describing apostrophe as a "symptom of diminished vital energy;" and although later discoveries have shown that this is too wide an assertion, yet there seems to be no doubt that to abnormal apostrophe, whether positive or negative, this description well applies.

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* I have obtained fair verification of this statement.

Fourthly. If the protoplasm of aerophytes be more highly toned, as respects light, than that of aquatics, it ought to betray more rigidity in the former; thus the positive effects of light should be less and take longer to bring about in the aerophyte than in the aquatic. That the disturbance caused by light is greater in the aquatic plant has been amply shown; its more rapid introduction is established by the table on p. 234, from which it may be gathered that even in low light the grains of *Elodea* require little longer to apostrophize than do those of aerophytes in direct sunlight (in good light a few minutes are sufficient for the purpose); and in bright diffused light *Lemna trisulca* chlorophyll is apostrophized in about a quarter of the time necessary for that of insolated aerophytes. Again, it is seen from the table that the almost entirely negatively apostrophized grains of *L. trisulca* are epistrophized in thirty-five minutes, whereas a corresponding movement in aerophytes is not completed until several hours have elapsed. Further comparison on this head is scarcely practicable, because of the long time required to negatively apostrophize the grains of aquatics, and the consequent inroads upon the health of their protoplasm. However, with this caution it may be pointed out that the partially apostrophized grains of *Utricularia vulgaris* were epistrophized in four hours, while the countermovement occupied half as many days, four hours being about the time taken by ordinary aerophytes to recover from the effects of only a few hours' withdrawal of light. Perusal of the table will make it evident that many similar facts could be cited were such a course deemed requisite.

Fifthly. By the parallelism shown in positive and negative apostrophization, clear proof is given that to neither movement does welfare of the chlorophyll stand in any necessary relation. This has already been spoken of; it will be sufficient here to remark that adherents to Böhm's theory must not only admit that insolation is more harmful to chlorophyll than withdrawal of light; they are bound to maintain that the difference in the amount of injury accruing from these two causes is much greater in the case of aquatic types than of sun-loving aerophytes, for the grains of the former (more readily apostrophized in sunlight) take a much longer time over negative apostrophization than do those of the latter.

Sixthly. But, it may be asked, how is it possible to explain the massing of chlorophyll upon continued insolation except, as Stahl does, by supposing it to be a method whereby the injurious effects of strong light are minimized? The fact that massing also takes place in darkness, although a good, is scarcely a clinching argument against the protection doctrine, since similar results may ensue from dissimilar causes: there can also be no doubt that the massed chlorophyll *is* less exposed to light because of the shadow which some of the grains are now able to cast upon their neighbours; besides this, it is shown on p. 231 that massing is the cause of some of the grains being forced upon their edge, and so partially withdrawn from the sun's influence. If, however, it is possible to refer massing to purely mechanical action, it is submitted that the protection doctrine must be abandoned, since the directive effects of light now vanish. Such mechanical considerations are easily reached. Suppose a cell whose chlorophyll has just been positively apostrophized. The grains now lie uniformly disposed around the cell, and, in virtue of the disturbance of the molecular equilibrium induced in protoplasm by light, they shift their position, remaining all the while, for photometric reasons, upon the lateral walls. This movement can be traced in some cases, as *e.g.* in the marginal cells of *Lemna trisulca*, but the observation is a trying and tedious one; its speed depends on the ratio between the protoplasmic momentum on one hand, and friction and inertia on the other. It is obvious that at the corners of rectangular and in the arms of mesophyll cells the friction will be at its maximum; the consequence of this is that the grains in the arms or corners will be caught up by their successors, and, being impinged upon by the latter, a loss of momentum will ensue; and as the inertia of the massing grains is a constantly increasing quantity, it is clear that the retarding influences are ever becoming greater, so that a time must arrive when the energy accumulated in the protoplasm is no longer capable of setting the heaped masses in motion.

Suppose, now, the chlorophyll to have undergone negative apostrophization. This has already been referred to recovery from the strain imposed by epistrophization, but massing in the dark seems due to another agency. We know that the epistrophic interval is curtailed towards the right by any condition tending to depress the vitality of protoplasm; it has also been insisted on that the motile effects of light do not immediately disappear when a plant is placed in darkness; nay, that they may remain evident for weeks. Lowering of the vitality of protoplasm is therefore accompanied by increase in its sensitiveness to light; if this lowering take place before the motile effects of light have soaked out, the protoplasm is acted upon precisely as if, while retaining its normal vitality, it were exposed to apostrophizing grades of illumination. It is claimed that darkness exerts the required lowering effect upon protoplasm; and, if this view be correct, and it will, perhaps, be considered no extravagant hypothesis, there is ample justification for the surmise that, if the movements of epi- and apostrophization concern protoplasm alone, the apostrophized grains would, for the same reason and by the same means which have already been mentioned as coming into play in respect of positive effects, mass in the corners and arms of their cells.

The position here taken up is selected for the following consideration. If it be held that lowering of the protoplasmic tone is the sole reason for negative apostrophization, it seems difficult, if not impossible, to believe that there can be the required difference in this respect between aerophytes and aquatics, while, if simple relaxation from tension be the sole cause, the chlorophyll having been negatively apostrophized should, instead of massing, remain uniformly distributed upon the lateral walls. The latter condition is found in *Funaria hygrometrica*, the grains of which, instead of speedily massing in darkness, remain in simple apostrophe. In this case it might be argued either that the effects of light must soak out with unusual rapidity (in which event we should expect that rearrangement of the grains consequent on long confinement in the dark, to which the name of "negative epistrophe" or "astrophe" has been given, would set in much sooner than is the case), or else that the tone of the protoplasm with respect to light must be rapidly lowered (which would result in ultimate massing—a very rare occurrence indeed in *Funaria*). The difficulty will, perhaps, vanish when it is remembered that the thickness of the *Funaria*-cell is much less than its length, so that the grains, very large relatively to the size of the cell, are more closely packed in apostrophe than in epistrophe; by this means the conditions favouring stasis are reinforced by impact of the grains against their neighbours, and the consequent loss of momentum and increase of friction. This, it is easy to conceive, may well be equivalent to the difference between the above conditions and the protoplasmic momentum; and if equivalence be once established, massing cannot set in.

The theory here advanced may be shortly stated thus:—

(1) Protoplasm is positively phototactic to light of medium intensity, and negatively so to high grades of illumination and to darkness.

(2) The attracting and repelling actions of light impose a strain upon protoplasm, the time of recovery from which varies directly as the amount of the strain, *i. e.* as the sensitiveness of the protoplasm to light, and directly also as the period of exposure.

(3) Lowering of the tone of protoplasm as respects light results from withholding that agent; at the same time photolytic effects remain stored up for a time in protoplasm after light has been shut out. It is upon the relation between lowering of the tone and soaking out of the effects of light that negative apostrophe depends.

The view here advocated does not exclude the new doctrine, that it is mainly by the movements of protoplasm that the transference of plastic materials from one part of a plant to another is effected. The doctrine may be said to be new because of the great extension of which it is capable from the discovery of protoplasmic continuity. It is well, however, to remember that

Crüger*, more than thirty years ago, considered that nutritive materials might be conveyed by the streaming plasma, and such conveyance was actually observed by Strasburger† in the course of his study of cell-division in *Spirogyra.* Meanwhile Velten ‡ had put forward the notion that protoplasmic movement is of universal occurrence in the vegetable cell. It was left for H. de Vries § to apply Velten's view to the altered ideas of cell-life introduced by the continuity doctrine, by maintaining that the transport of materials is brought about by circulatory or rotatory actions in the connected protoplasts. De Vries takes his stand upon Stefan's‖ calculations, according to one of which, for instance, one milligramme of sodium chloride in 10-per-cent. solution requires 319 days to traverse, by means of diffusion in water, the space of a metre; his own experiments with vertical tubes, in the bottom of which he placed some coloured salt in a dry state and then cautiously filled the tube with water, indicated a rate of diffusion wholly inadequate to account for the rapid transport of materials through the tissues of plants. He also made a large number of observations which showed the universality of protoplasmic movement. In these experiments portions of tissue were laid in a 5-per-cent. solution of cane-sugar, in which they were allowed to remain from one to two hours before examination. Under these circumstances either circulation or rotation was usually set up, and was especially well pronounced in the conducting-cells of the phloem, *i. e.* where the transport of materials is at its maximum. It may be objected to De Vries's vertical-tube experiments that they do not reproduce natural conditions with anything like exactitude; still, even allowing for this, there does seem to be much force in his argument, although one is not bound to admit that the normal movements of protoplasm are as energetic as were those observed by him, in which latter I am inclined to think there are three factors concerned, viz.: 1st, a slow motion, similar to but perhaps slightly more rapid than that by which photolysis is effected; 2nd, increase of illumination; and 3rd, lowering of protoplasmic tone—the last two being the result of sectioning. It does not appear that 5-per-cent. solutions of sugar exert much, if indeed any, lowering action upon the protoplasm of intact organs; at least this applies to uninjured *Elodea*-plants both in the dark and in diffused light. After three days the chlorophyll of leaves from specimens grown in sugar-solution may show slight tendency to apostrophe; but this is not always the case by any means.

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* Bot. Zeitung, 1855. Crüger did more; he even suggested that transport of nutriment from cell to cell might take place *viâ* pores in the cell-wall; in fact, his theory is in all essentials the same as De Vries's.

† 'Ueber Zellbildung und Zelltheilung'; also 'Bau und Wachsthum.'

‡ Bot. Zeitung, 1872.

Bot. Zeitung, 1885; most of the bibliography is given in this memoir.

Sitzungsb. der k. Wiener Akad. 1879, ii. Abtheilung.

On the assumption by Chlorophyll Grains of profile position with respect to the wall upon which they are placed.

It becomes necessary to contest the correctness of another of Stahl's views. He remarks*, *à propos* of *Elodea canadensis*, that when the chlorophyll grains run together into clumps on exposure to direct sunlight, the greater number, especially those lying at the outskirts of the clumps, are tilted up so as to present their edge to that wall of the cell upon which they are ranged. Stahl considers that this is brought about by spontaneous movement of the grain upon its own axis, its object being to save the grain from broadside illumination. Here, however, he is quite in error. It is, indeed, the fact that such set-on-edge grains are to be seen in the cells of *Elodea*-leaves exposed to sunlight and high diffused illumination; but I have never found any large proportion of the grains of a clump in this position, and with regard to those so placed, it is easy enough by careful examination to ascertain how the state of things was brought about. It has already been mentioned that, when leaves of *Elodea* are exposed for a few minutes to strong sunlight, one may often see two grains start from opposite sides of a cell, run along the intervening bridge of plasma and clash, one of them turning upon its edge while the other remains upon its side, and that the grains are in this way enabled to pass each other. A grain thus forced upon its edge may either remain so until it reaches and glides upon the side-wall without shifting upon its axis, or it may strike another grain or group of grains, and in consequence either turn over broadside again or remain upon its edge, pressed closely against the obstacle. It is safe to affirm, therefore, that the grains which Stahl speaks of did not, as he thinks, spontaneously turn on their edge (he does not profess to have seen such spontaneous movement), but assumed that position in consequence of abutting on the clumps. But, so far as my own experience goes, this is due to local disturbances in the mass of protoplasm which invests the grains composing the clumps, whereby abnormal pressure is caused at certain points. Even were not this a matter of easy observation, Stahl's doctrine is exceedingly questionable, for it might he asked with reason why, if the end of the movement is to guard the grain from undue action of the sun, should it be restricted to a small percentage of the grains? In fact, this edgewise position has nothing in the least degree peculiar about it, for a broadside grain in motion, when it reaches and strikes against the top of the wall at right angles to that upon which it has been moving, turns up on its edge just as would have been the case had it come in contact with a clump. Another instance of this is shown at fig. 14 (Pl. VII.), which represents part of a cell with protoplasm in vigorous rotation, the plane of the rotating stream lying, as sometimes occurs, at one point in the plane of the leaf instead of perpendicular thereto. In this case, when the grain reaches the point where the stream runs broadside to the observer, it is forced away from the side wall and immediately moves upon its own axis through an arc of 90°, reverting to the former position on again coming in contact with a lateral wall.

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* Bot. Zeitung, 1880, p. 337.

Moreover, bearing upon this point is other evidence, less easy to collect, it is true, but not less conclusive. The more slowly-moved grains of ordinary plants may frequently be found when they collect into clumps set with their edge to the wall; and by keeping preparations under observation for some time, it is no very difficult matter to determine that here, as before, pressure, and pressure alone, is the cause of this. Figs. 11 *a, b, c,* show this; they are taken from the prothallus of a fern, probably a species of *Adiantum*. In the first of these we see the grains in the left-hand cell, under the direct influence of the sun, making for the wall, which several of them have reached; a second row abuts on the first, and has in consequence been forced to stand edgewise, while a few outer ones are still on their face. In the next figure, drawn after the prothallus has been for half an hour in the shade, the tendency of the grains is to move from the side wall, and all but one of them have turned on to their face, the exceptional grain remaining wedged in between its neighbours. Fig. 11 *c* shows the position of the grains after the prothallus has lain in the shade two hours longer. Here the progress towards epistrophe is still more marked; but the edgewise grain has not yet obtained sufficient room to permit of its turning face-up. Similar in every respect was the behaviour of the grains of *Funaria hygrometrica* leaves moving into positive apostrophe, and abutting upon their fellows which had already reached the wall (Pl. VII. fig. 12); as also those of *Vaucheria* sp., and in the long barrel-shaped cells of the leaves of *Echeveria metallica* edge-set grains were seen many hours after withdrawal from direct sunlight (fig. 13).

It must be remarked that in the cells of plants with slow-moving protoplasm it is much rarer to find edgewise grains than in those of *Elodea*; this is only what would be expected when it is remembered that variations in pressure at different points of the plasma are necessarily less frequent and less violent in the former types.

But the *coup de grâce* is given to Stahl's doctrine by the fact that the grains of *darkling* plants may occasionally be found upon their edge. I have seen this in examples of *Elodea* and *Vallisneria* set in the dark for several days; and at fig. 10 is shown an edgewise grain in a clump massed in an epidermal cell of *Pteris serrulata* kept in darkness for three weeks; this last period is, as has already been seen, sufficient to cause the apostrophized grains of *Funaria hygrometrica* to come out upon the surface-walls (negative epistrophe), in which position they can here and there be found tilted up on their edge, it being sometimes possible to refer the peculiarity directly to the effects of pressure exerted by surrounding grains (fig. 4). The negatively apostrophized grains of higher plants may also sometimes be found in profile in places where they abut upon their fellows.

The Law of Positive Progression.

It has before now been noticed* that the grains of a plant brought out of darkness into diffused light more quickly pass into epistrophe than they do into apostrophe when removed from diffused light into darkness. This rule I find to be, so far as my experience goes, of universal application; and not only so, but the fact is but a part of what seems to be a general law. Not merely is it true that more time is required to induce nega-

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* First by Borodin, in 1867.

PLANT.	1. Negative apostrophe from epistrophe.	2. Epistrophe from negative apostrophe.	3. Positive apostrophe from epistrophe.	4. Epistrophe from positive apostrophe.
Elodea canadensis	10 weeks (Frank).	A few days (Frank). Recovery from 3 weeks' darkness within 4 days.	80 minutes (in low light).	Usually about 24 hours.
Lemna trisulca	Nearly perfect in 6½ hours; not complete in 3 weeks.	Recovery from 6½ hours' confinement in 35 minutes; from 3 weeks' in about 2 days.	½ hour *.	1 hour.
Callitriche verna	Nearly perfect in 3 weeks †.	Not observed.	25 minutes *.	80 minutes.
Utricularia vulgaris	Not perfect in 2 days.	From 2 days' confinement in 4 hrs.	Within the hour (low light).	Not observed.
Hypnum fluitans (larger cells at base of leaf).	Incomplete after upwards of 4 weeks.	Recovery from 4 weeks' confinement in as many days.	Not observed.	Not observed.
Pteris serrulata (mesophyll of frond).	Incomplete in 4 weeks.	Recovery from 4 weeks' darkness in 3 days.	About 1 hour.	2 hours.
Oxalis Acetosella (lowest layer of mesophyll).	10 days.	3 days (inclusive of intervening nights).	About 1 hour.	Not complete in 3 hours.
Saxifraga granulata (mesophyll of young leaf).	Very incomplete after 3 weeks.	4 days.	1 hour.	Not commenced in 1, complete in 22 hours.
Funaria hygrometrica ...	5–6 hours.	3½ hours.	About 1 hour.	2 hours.
Eschscholtzia californica (leaf-mesophyll of a seedling).	Within 6–18 hours ‡.	3½ hours.	Within 1 hour.	2 hours.
Stellaria media (mesophyll of leaf).	5 hours.	3½ hours.	Within 1 hour.	Not complete in 3½ hours.
Vicia Faba (stipule, mesophyll).	Between 4½-22 hours.	4 hours.	½ hour.	3 hours.
Nigella damascena (mesophyl of primordial leaf).	Between 6–19 hours.	2 hours.	1 hour.	Incomplete in 2¼ hours.
Centranthus ruber (leaf, mesophyll).	5½ hours.	4 hours.	Within 1 hour.	3 hours.
Pyrethrum Parthenium (leaf, mesophyll).	5 hours.	2½ hours.	Within 1 hour.	3 hours.
Pyrethrum sinense (involucral scales).	Between 6–17 hours.	3–4 hours.	Within 1 hour.	Not commenced after upwards of an hour.
Senecio vulgaris (outer scales of involucre).	5 hours.	Not observed.	Within 1 hour.	2½ hours.
Urtica urens (stipules)...	Between 6–18 hours.	Between 3 and 4 hours.	1½ hour.	2½ hours.
Poa annua (leaf-sheaths)	Only slight signs in 3½ hours.	3½ hours.	Within 1 hour.	Not complete in 3 hours.

* Weak sunlight was employed in these cases. † Cells at the apex of the midrib require less time. ‡ Grains *massed* in 18 hours.

tive apostrophe from epistrophe than *vice versâ*, but the assumption of epistrophe from positive apostrophe is slower than that of positive apostrophe from epistrophe. Moreover, it always takes less time to bring about positive apostrophe from epistrophe than epistrophe from negative apostrophe, and epistrophe from positive apostrophe than negative apostrophe from epistrophe. This may be expressed in a general way by saying that as an advance is made towards the positive end of the photrum, the corresponding movement of the chlorophyll is performed with more despatch, while the reverse is the case in proceeding towards the negative end. This it is proposed to call the "Law of Positive Progression."

The accompanying Table (p. 234) contains all the information upon this subject I have been able to collect. It will be seen that three classes of types are included, viz. aquatics, shade-loving aerophytes, and ordinary plants. Compared with these last, aquatics require a relatively enormous period to fulfil the condition expressed in column 1, and in this point shade-lovers greatly resemble aquatics. The same may be said for column 2, but the difference here is less. With regard to column 3, had sunlight of good quality been used for inducing apostrophe in the aquatic types, the times in their cases would have been much shorter than those required by the rest; but it was thought advisable not to use the highest light with them, in order the more distinctly to emphasize the Law. The reason for the large intervals of time which appear in the lower part of the Table is that the determinations were made on the short November days, when, until nearly noon, the chlorophyll is imperfectly epistrophized[*], and microscopic examination is practicable only for a few hours thereafter. It should be added that care was taken to eliminate heating effects by the frequent pouring of cold water over plants whose chlorophyll was in process of positive apostrophization.

Some Points in the Rotation of the Protoplasm of Elodea *and* Vallisneria.

In speaking of photolysis in *Elodea*, it was pointed out that the chlorophyll of the upper is more readily apostrophized than that of the lower layer of cells; the same thing is to be said with respect to rotation[†]. It matters not in what position a leaf be placed, whether the upper layer receive the first impact of light or *vice versâ*, provided that the leaf be healthy, rotation is more rapidly set up in the cells of that layer. The statement is also true, as is well known, of pieces of *Vallisneria*-leaf, whether slit down longitudinally or not, only here the area of readier disturbance is that occupied by the large cells, many times longer than broad, which are found beneath the surface. In the case of *Elodea* photolytic difference between the two layers was held to be largely due to difference in the tone of the protoplasm with regard to light, because other possible causes of discrepancy, such as variation in the relation between protoplasmic momentum and number and size of chlorophyll grains, as well as in the form of the cells, were here absent; and I am disposed, for want of a better, to extend this idea so as to embrace the facts of rotation in this type. But it seems certain that the notable difference in the form of the small outer and the much longer inner cells of *Vallisneria* must exert some influence upon rotation. For the stream of protoplasm, slowly moving along the side of a long cell, will not only undergo the diminution of its velocity consequent on turning a corner less frequently than must necessarily happen in a small cell, but the uninterrupted flow of the stream down a long side will enable it to acquire sufficient momentum to carry it round a corner sooner than would be possible in a small cell [*]. Besides this, it must be remembered that there is relatively less chlorophyll in the inner than in the outer cells, and, consequently, less inertia to be overcome by the protoplasm. These considerations are, perhaps, applicable without reserve to the long narrow midrib-cells of *Elodea*-leaves, in which rotation sets in a little sooner than it does in the surrounding tissue [†]; but the very great diversity in this respect between the large and small cells of *Vallisneria* would seem to denote a difference in the tone of the protoplasm as being, perhaps to a less extent than in *Elodea*, contributory to the phenomenon in question.

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[*] Sometimes on dark days the grains do not move into epistrophe at all.

[†] This is noticed by Frank (*l. c.* p. 240).

It is well known that rotation in detached leaves of *Elodea* can be stopped by their removal to darkness; but what has not been explained is the varying length of the time required to bring about stasis. Two leaves, similar in all respects apparently, may be illuminated under precisely the same conditions; yet in the one rotation may still be in progress some time after its cessation in the other. Now it is admitted by every one that rotation is merely a sort of exaggeration of photolysis; consequently the phototactic doctrine previously advanced in this memoir with reference to the latter will apply in every way to rotation which, when in progress, proclaims that the apostrophizing factors have triumphed over the epistrophizing ones. What are the factors favouring apostrophe and rotation apart from the form and chlorophyll-contents of the cell? Obviously (1) the strength of illumination, because the more to the right of the positive critical point the plant is set in the photrum, the more rapidly will rotation ensue; and (2) any lessening of the capacity of the protoplasm to resist the motile agency of light upon it. If, therefore, illumination be identical in the two *Elodea*-leaves, an increase in the time of recovery from rotation must depend upon difference in protoplasmic tone; and it is clear that the higher the tone, the less is the advantage gained by the apostrophizing forces over those which make for epistrophe; so that, as the motile effects of light soak out in darkness, stasis—or rather a condition near stasis signalized only by the slight movement whereby chlorophyll is epistrophized—must, other things equal, sooner supervene the higher the tone of the protoplasm.

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[*] Velten has shown that the protoplasmic stream tends to flow in the direction of least resistance (see 'Flora,' 1873, p. 87).

[†] It is worthy of mention that positive apostrophe is more readily induced in the long narrow cells of the midrib of leaves than in the cells of the lamina.

In fact, the protoplasm varies in tone to a very great degree. As an instance, the cells in the neighbourhood of discoloured spots of *Elodea*-leaves are instructive. The spots referred to are small discolorations affecting one or a few cells, the cell-sap, and apparently the protoplasm, of which are turned dark brown, red, or purple, the chlorophyll grains remaining in epistrophe, wherefrom they cannot be moved by light. It would appear that these cells, which are of common occurrence, have been injured by small aquatic creatures or in other ways. The facts about to be described are so universal that they can have but one explanation. If an *Elodea*-leaf with one or more discoloured spots be cut off a plant growing in low light and set in good diffused illumination, or in the sun's rays, the cells in the neighbourhood of a spot will have their grains in apostrophe at a time when those of remoter cells will still be, for the most part, upon the superficial wall; and before the running together of the grains upon the surface-wall has ceased in the latter, in the former rotation will be well established. Moreover, had the leaf been set in light just sufficiently strong to apostrophize the chlorophyll of the remote cells without inducing rotation in them, those near the discoloured spot would have had their protoplasm in rotation; and if the quality of the light had been somewhat poorer, so that the epistrophe of the remote cells was not interfered with, the cells near the spot would have been the theatre of apostrophe. This latter fact was referred to on p. 218, and illustrated in diagram 3; and if the explanation there given be sound, namely, that the proximity of a dead cell tends to diminish the vitality of protoplasm and consequently to increase its sensitiveness to light, it will not be less sound when extended to the other facts, which are of a closely allied nature. Thus we have a striking confirmation of the idea that rotation is but photolysis in a more violent form; and, moreover, the previously urged modification of Frank's notion that (abnormal) apostrophe is "a symptom of diminished vital energy" is seen to apply to abnormal rotation also.

Rotation is well known as more readily setting in at the edge of *Elodea*-leaves than in the lamina*. This I am inclined to attribute to the early decay of the cells which project from the lamina to form the teeth, by which means the edge becomes a zone bordering on dead or dying cells—that is, a zone of abnormal rotation.

On p. 226 it is stated that poisons cause apostrophe to set in more readily than under normal circumstances; they play the same part in respect of rotation. Thus if healthy *Elodea*-plants with epistrophized grains be placed in a solution of ferrous sulphate not strong enough to induce plasmolysis, many of the cells of still-attached leaves will have their protoplasm with all their chlorophyll grains in rotation within twenty-four hours, and within forty-eight hours rapid rotation will be general. This is true not only under positive conditions, but under negative also, removal to complete darkness immediately on placing specimens in ferrous sulphate sufficing to bring about rotation. Whether this is more quickly effected in darkness than in light has not yet been determined; though the few experiments which I have been able to make tend, upon the whole, to show that such is the case, but to a limited extent only. The reason for this seems to be as follows. In the darkling plants the early setting-in of rotation is favoured by the lowering of the protoplasmic tone by darkness and by the poison; opposed to this is the stored-up and only slowly-soaking-out action of light tending to maintain epistrophe. The lowering effect of the poison is, in the illuminated specimens, operant to the same degree as before, and it is reinforced at night by the action of darkness; but during the daytime this latter action is, if the light be not too strong, exchanged for the epistrophizing tendency of medium diffused light. It is clear that the light used must not be too intense; otherwise, instead of favouring epistrophe, it will take part in driving the protoplasm and chlorophyll on to the lateral walls, which it will be enabled more easily to do from the lowering in its tone experienced by the protoplasm as a consequence of poisoning. It was perhaps from experimenting with light of too high quality that in some cases no appreciable difference could be detected in this matter between darkling and exposed specimens; but I hope to obtain further information upon this point. It usually happens that the death-stasis, into which rotation from poisoning passes, ensues more rapidly in darkness than in light; this is only what would be expected, seeing that rotation from poisoning makes an earlier appearance in the dark, in addition to which the absence of light is a factor favouring the cessation of vitality.

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* Usually the protoplasm of the midrib-cells enters earliest into rotation.

The analogy of the epistrophic may be applied to the construction of a "cyclolytic" interval, the left-hand end of which will be very near to the positive critical point, without actually reaching it however, because, in poor light of just the requisite intensity, it is possible to apostrophize the chlorophyll of *Elodea* without any rotation supervening even after several hours. Towards the right the cyclolytic interval will extend as far as that degree of concentrated sunlight at which the movements of protoplasm are arrested. Moreover, the extent of the interval will vary with the protoplasmic tone, any lowering of which will be accompanied by the former's leftward development: it will also depend upon the position of the cell; thus the interval of the upper cells of *Elodea*-leaves will extend further to the left than will that of those of the lower layer.

The Effect of Sectioning on Rotation.

Frank* has ascribed rotation in its best exhibited form to the sectioning which is usually practised in order to see it. This idea is quite erroneous; for not only can protoplasm be set in rotation without any injury to the plant, but under certain conditions sectioning can be practised without rotation following; that is, the result can ensue without the intervention of the supposed cause, which latter does not necessarily carry rotation in its train.

As an instance of the way in which wrong notions upon this subject can be generated, the following experiment may be cited. Longitudinal and transverse sections of neighbouring *Elodea*-leaves were divided into four sets; two were mounted in water on a glass slide and covered with cover-slips, two placed in shallow vessels filled with water. One from each of these two was immediately removed to darkness, the others being brought up to a window on a dull August day, temperature in both cases 66°·5 F. Examined an hour later, the temperature at the window having meanwhile risen to 67°, it was found that rotation was fairly general over the illuminated portions of leaf, and was well established in the cells on the section-edges of the darkling ones. The inference from this was obvious: it was only when attention was paid to the fact that in the neighbourhood of discoloured cells of the darklings vigorous rotation had set in, there being spaces of quiescent protoplasm separating the disturbed areas from each other and from the cut edge, that the existence of some cause for rotation other than mere sectioning was suspected; otherwise, why should the areas of disturbance be scattered, seeing that on the section hypothesis rotation should appear first at the section-edge, and progress therefrom uniformly over the leaf?

In fact, it usually happens that *Elodea*-leaves sectioned longitudinally, transversely, or obliquely, within an hour of the operation have some, at least, of their cells at the section-edge with rotating protoplasm, even if the plant furnishing them has been growing in low light, and the light by the aid of which the section has been made has been only sufficient to just see by. A large number of experiments were made upon this point; but the amount of rotation which declared itself after a given interval varied to so extraordinary a degree, that I was for a long time completely baffled for an explanation. In one case the edge of a section would show only faint signs of rotation, which in another from a neighbouring leaf was well established the whole length of the section, while a third would be in an intermediate condition. It was only after grasping the idea that negative rotation, like negative apostrophe, is the expression of the preponderance of the unexhausted or potential effects of light over the tonicity of the protoplasm, that the mystery appeared to be solved. Rotation at the section-edge was then seen to result in precisely the same way as that around dead cells, the operation of sectioning destroying the cells at the edge, which then act the part of discoloured cells as depressors of the vitality of their neighbours' protoplasm. The variations in the amount of rotation were now seen to be due either to initial difference in the quality of the protoplasm in the cells abutting on the section, or, what amounts to the same thing, to the presence of one or more dead cells along or near the sectioning line.

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* Pringsheim's Jahrb. f. wiss. Bot. Bd. viii. So anxious was Frank to emphasize the effect which preparation has upon rotation, that although he observed rotating protoplasm in the internal cells of uninjured *Vallisneria*-leaves, he maintains that this form of rotation differs from that which ensues upon sectioning, inasmuch as only a few of the chlorophyll grains are carried into the stream. Had he allowed more time and used better light, he would have found this alleged difference to be purely imaginary.

But it has been said that a leaf may be sectioned without rotation being set up in the cells at the section-edge; and if the doctrine here advanced be sound, it is obvious that this might well happen. For suppose the potential effect of light to be equal in two cases, it might be surmised, and surmise would be borne out by experiment, that rotation will first be established in that case where the protoplasm is of poorer quality; and in the other it might happen that rotation will not appear at all, because the protoplasm would be so highly toned as to be able to resist the tendency of sectioning to bring it down to the required point. Successful resistance to rotation upon section should, then, be met with in uninjured leaves immediately after their removal from healthy plants growing under the most favourable conditions; in fact, these are the only leaves which have been found capable of resistance. Thus, in one experiment, a leaf was cut off a vigorous plant removed a few hours before from a large pond, and kept in low light meanwhile. This was at 10.40 A.M.:

and at 2.20 P.M., on removing the two sections from darkness, no rotation at all was observed in one portion, and in the other only in the immediate neighbourhood of a discoloured spot near the margin, but far away from the section-edge, and in one cell near the base close to a purple discoloration of the cell-sap*. That sectioning had lowered the protoplasmic tone was evident from the fact that the chlorophyll in the cells upon the section-edge was for the most part in apostrophe, epistrophe of course prevailing elsewhere.

Moreover, rotation at the section-edge can be stopped by withholding light. In a piece of leaf with rotation in the edge-cells set over-night in darkness, quiescence may be established on the following morning, but frequently a longer time is required. This is only what would be expected; for the condition of equilibrium between the tonicity of protoplasm and the cyclolytic action of light which has been upset by sectioning would tend to be restored when the direct access of light is prevented.

With respect to *Vallisneria*, I have not found that sectioning is not necessarily followed by rotation in the large inner cells of the leaf, even if the utmost care be taken to protect the leaf from undue illumination during sectioning. There are two causes for this failure: one is that the *Vallisneria*-plants obtained of the dealers, growing as they do under artificial conditions, cannot be in a very robust condition; the other seems to reside in the form of the cell and in the relatively small size of the chlorophyll grains—both circumstances favourable to rotation, as has already been mentioned. This question can be decided only by an appeal to healthy plants growing in their native haunts.

But whatever doubts *Vallisneria* may cause as to the error in Frank's doctrine, that error is plainly manifested when the protoplasm of intact organs is set in rotation. In view of the ease with which this can be done, it is astonishing that incorrect notions should have prevailed so long upon the subject†. Moreover, rotation without injury is similar in every respect to that which follows upon sectioning, as the following experiment, among others, will show. An *Elodea*-plant was placed in a moist bag, its tip only protruding. The bag having been fixed to a cardboard frame, one of the leaves at the tip was spread out in water on a small glass stage fixed in a hole in the cardboard, and covered with a thin cover-slip. The leaf was then arranged on the microscope-stage so as to be illuminated by the mirror; and in half an hour rotation had set in. At 2.30, fifty minutes after beginning the experiment, the bag and its contents were removed to the dark; and at 6 o'clock that evening the protoplasm was slowly rotating. At 8.40 next morning there was still faint rotation near the apex of the leaf; but by 12.45 on the day after complete quiescence had supervened. A still more satisfactory observation—in that temperatures were carefully noted—is the following. An *Elodea*-plant was placed in a shallow vessel nearly filled with water, set on the sill of a window facing north. At midday the protoplasm was in slow rotation, the temperature of the water being 57° F.; and the vessel was now set in darkness in a south-facing room. Examined at 8.40 P.M., the temperature of the water being now 63° F., rotation had stopped, and the grains were in epistrophe. Next morning the vessel was replaced on the north side of the house, and, rotation having been induced, removal to darkness was effected at 2.30 P.M.; at 6.15 the same evening rotation had ceased except in one cell of the midrib, in which it was very faint—temperature in both light and darkness 65° F.

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* It should not be forgotten that the leaves must be cut in very low light: in the above and similar experiments the room was darkened by drawing down and shutting close a venetian blind at the only window.

† Frank describes rotation in old and apparently intact leaves af *Elodea*. See also footnote on p. 240.

It is unnecessary to dwell more upon this point; but some investigations, of which *Vallisneria* was the subject, may here be detailed. A young *Vallisneria*-plant which had been kept for several days in a vessel placed in low light, and showed no trace of rotation, was removed on a dull August day to a small glass jar containing water, in which it was totally immersed, and brought up to poor diffused light, undergoing less than 1° variation of temperature by the process. When observed two and a half hours afterwards, rotation was found to have been set up in the large internal cells*. The jar was now (3.15 P.M.) removed to the dark chamber, and rotation was ascertained to be in progress throughout the following day; but at 5 o'clock in the afternoon of the third day all movement had ceased. Light was then admitted until the protoplasm recommenced to rotate, when the agency of darkness was again invoked, after which stasis again set in. The process is, in fact, capable of apparently indefinite repetition.

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* This was observed by focussing through the superficial tissue—not a difficult task by any means. The grains were carried along in the protoplasmic stream just as happens upon sectioning.

Preliminary Study of the Influence of Light upon Rotation.

The many points of agreement between photolysis and rotation render very noteworthy the dictum of Hofmeister[*], that increase in the intensity of light does not markedly accelerate protoplasmic movement. The interest accompanying this statement, which is not pronounced affirmatively against by either Sachs[†] or Pfeffer[‡], is discovered when account is taken of its direct contradiction to another statement, easily verifiable, with respect to photolysis, viz. that the further a plant is placed in the photrum to the right of its positive critical point, the more rapidly will its chlorophyll be apostrophized. Moreover, it has been seen that the higher the illumination to which an *Elodea*-leaf with epistrophized chlorophyll is exposed, the sooner will rotation ensue in its cells. If, therefore, the inception of rotation is governed by the intensity of light, its continuance ought to be affected by that agency.

In experimenting on this subject there is one matter requiring careful attention. In order that the effect of enhanced illumination may be brought into view, it is necessary that the rotating stream be moving at a rate much below the maximum; if its speed be great, very little, if any, acceleration will ensue in higher light, because, just as a definite quantity of work and no more can be got from a machine, so only a certain velocity can be impressed upon protoplasm. It is this capital point which has been overlooked by all experimenters. So far as the after-mentioned observations made with it in view go, a marked acceleration of rotation takes place in light of improved quality. The way in which this kind of experiment is usually conducted may be instanced as follows. Upon a September afternoon, the temperature of the room in the shade being 70° F., rotation was well set up in an *Elodea*-leaf plucked off two hours previously, and exposed meanwhile to medium diffused light under a cover-slip upon a glass slide. At this time the side of a marked cell was traversed by the rotating stream in an average of thirteen seconds. The leaf was then brought up to direct sunlight, care being taken to prevent rise of temperature by constantly irrigating it with cold water at the temperature of the room. After ten minutes' direct insolation, the side of the cell was still traversed in thirteen seconds, thus indicating to all appearance that enhanced illumination does not quicken the rate of movement. But the facts may be at least as well explained upon the supposition that the indicated rate of movement is the maximum possible at the given temperature—a supposition backed by the two following results obtained from *Elodea.* Both were made on days favourable for the purpose, chequered by rapidly alternating high and low lights. A day with plenty of wind driving along large masses of white and neutral-tinted cumulus cloud over tracts of sky occasionally revealed should be selected for this experiment.

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[*] 'Pflanzenzelle,' p. 49.

[†] 'Vorlesungen,' Chapter xxxv.

[‡] 'Pflanzenphysiologie,' ii. p. 386.

No. I.

Time.	Light.	Temperature.	Side of marked cell traversed in
4.25 P.M.	Rather poor, some heavy clouds just passed over.	64° F.	30 secs.
4.35 P.M.	Light much better.	64° F.	24 seconds.
4.45 P.M.	Still further improvement in light.	64° F.	20 seconds.
4.55 P.M.	Somewhat poorer, rather dark clouds passing over.	64° F.	25 seconds.
5.5 P.M.	Improved, the S.W. side of passing clouds brightly lit up.	64°·5 F.	20 seconds.

No. II.

Time.	Light.	Temperature.	Side of marked cell traversed in
12 o'clock 12.15 „	Fairly good, heavy black clouds just passed over at 12 o'clock.	64°·8 F.	25 seconds.
12.30 „ 12.45 „ 1.0 „	Distinct improvement in light, which was of approximately the same average intensity at all three periods.	64°·8 F.	20 seconds.

It will be understood that in neither case was the rotation allowed to approach its maximum. No. II. shows the equability of the stream under continued similarity of illumination.

The facts upon these tables can be verified without great difficulty; but with the *Characeæ* it is different. The slowing of the protoplasmic stream in this group on withdrawal of light was studied half a century ago by Dutrochet[*], who found that in the old parts rotation had become slow by the eighth day, and had ceased by the sixteenth[†]; while in young parts cessation supervened by the twenty-fourth, or at most the twenty-sixth day, by which time etiolation had set in. Dutrochet regards the stoppage of the stream as an effect of asphyxia; and if his dark chamber was a small and hermetically sealed one, this might well have been the case. My own experience is different; for I have placed for a month, and even six weeks, in a large dark cupboard small pieces of *Chara vulgaris*, containing at least one uncorticated internodal cell[‡] with two or more uninjured nodes, without causing complete stoppage of the stream, although the diminution of its velocity after the above period was very evident. In order to bring this diminution clearly into view, the specimen, immediately on removal from darkness, was set in water on a glass slide, the light employed for this purpose being only just good enough to see by; it was then examined, uncovered, with a Hartnack's No. 7 objective, the time taken by a plastid or group of plastids in the centre of the stream to pass over a diameter of the field of view being rapidly noted. It only remained then to repeat the observation as often as necessary. The following were the chief results obtained with *Chara vulgaris.*

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[*] Comptes Rendus, xxxvii. p. 777, and Ann. d. Sc. Nat. sér. 2, ix. (1838).

[†] By an oversight, "sixième" is put for "seizième" in describing this.

[‡] Such uncorticated cells are well known as of rare occurrence in *Chara*.

No. III.

(Specimen placed in darkness August 10th: examined September 10th.)

Time.	Diameter of field traversed in
4.30 P.M.	40 seconds.
4.32 P.M.	30 seconds.
4.35 P.M.	15 seconds*.
4.37 P.M.	12 seconds.
4.40 P.M.	10 seconds.

No further increase of velocity occurred.
Temperature of dark cupboard 68° F.; of room 69°–69°·5 F.

No. IV.

(A month's darkness as before; temperature of cupboard and room the same within a fraction of a degree.)

Time.	Diameter of field traversed in
5.27 P.M.	65 seconds.
5.32 P.M.	20 seconds.
5.35 P.M.	15 seconds.
5.40 P.M.	12 econds.

After which there was no further increase.

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* Immediately before noting this the blind was drawn up, causing great improvement in the light.

A third experiment was made for the express purpose of ascertaining whether a fallacy might not reside in the above. Seeing that Dutrochet found the stream to be stopped by a little over three weeks' darkness at the most, it is highly probable, if not certain, that in the specimens used above some slowing had been effected in a month. Alterations in the speed of the current are introduced, as Dutrochet has shown, by shocks; it seemed possible, therefore, that the shock experienced by the specimen hurriedly brought into contact with the glass slide might diminish the speed of rotation. Accordingly the precaution was now taken of shutting in the dark for several minutes prior to examination the glass slide upon which the specimen had been placed.

The piece of *Chara vulgaris* was removed to darkness on September 15th, and on October 30th, after the treatment just mentioned (the temperature of the room being 62° F., of the dark chamber 61°·5 F.), on the first observation the diameter of the field was traversed in an average of 21 seconds; 2 minutes after only 16 seconds were required; 2 minutes after that 14 seconds; after another 2 minutes the space was moved over in 13 seconds, and in 11·5 seconds 5 minutes after the last determination. The specimen was now thoroughly irrigated with water at 61° F., the intensity of the light remaining constant; and 5 minutes afterwards the speed had slowed somewhat, the diameter of the field being now traversed in 13 seconds. Frequent applications of water at 61° F. followed, the effect being to prevent any slight change of temperature, to which alone the slowing just mentioned was to be attributed. Five minutes after this was done the normal rate was re-established, the field being passed over in 11·5 seconds; and this rate was maintained until the close of the experiment.

Thus we see from Table No. III. that although there was a difference of less than 1° between the temperature of the room and that of the cupboard, yet five minutes after exposure to light the stream was moving at nearly three times its former rate, and at four times ten minutes after. It is impossible to ascribe the whole of this increase to the slight difference in temperature between the room and the cupboard; and Table No. IV. plainly bears this out. Here, although there was no discrepancy of temperature, after only five mintues in light the rate of the current howed no less than four-fold acceleration. It is submitted that, so far as this evidence goes, there is reason to support the contention that increase in the intensity of illumination does markedly quicken the speed of the rotating stream.

On Negative Rotation.

One objection may be taken to the parallel drawn between photolysis and rotation. It might be urged, with justice, that if this parallel is a true one, it ought to exhibit itself under darkling conditions as well as in light. The chlorophyll of *Elodea* or *Vallisneria*, for instance, ought then, after apostrophizing in the dark—provided, of course, that death have not ensued—to commence rotating round the cell; so that just as high illumination and darkness are both inducers of apostrophe, so rotation should be the result either of an increase in the intensity of light or of its complete absence. I have not as yet been able to pursue this interesting subject far; but the facts which follow show that a form of rotation, which may be called "negative" in distinction from ordinary or "positive" rotation,—which, however, it precisely resembles—ensues upon prolonged withdrawal of light*. Moreover this might have been predicated from the massing in its cells' corners or arms which chlorophyll experiences when deprived of light, since it has been shown that such massing is a mechanical consequence of slow movement of the grains round the side-walls of the cell—in other words, of *feeble rotation*.

In both the external and the internal cells of *Vallisneria*-leaves after three months' darkness, rotation may be observed, not indeed throughout the leaf, but at a short distance from its dying apex. At the apex the cells are plainly dead, the protoplasm is quite motionless, and the small brown degraded chlorophyll grains are for the most part collected in little masses at various points. Below this comes a zone where the protoplasm carrying the small chlorophyll grains is in slower or quicker rotation. We have already seen that protoplasmic movement is more readily set up in the large internal than in the external cells; this applies, to a certain extent, to negative rotation, as movement can usually be traced in the internal cells a little further towards the leaf-base than in the external ones; and it frequently persists in the external distal cells a little longer than in their immediately underlying fellows. Further down the leaf the chlorophyll is in more or less perfect apostrophe; but after four months in the dark, I have found rotation to be in progress throughout the greater part of the leaf. It sometimes happens that massing of the grains in the cell-corners preludes rotation. Closely similar results are yielded by *Elodea*; but I am not in a position to treat of this matter in detail.

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* Frank noticed that the protoplasm of *Elodea* plants kept several weeks in darkness, and whose chlorophyll was in [negative] apostrophe, had passed into circulation; but no grains were carried along by the streaming protoplasm. Thus he nearly discovered negative rotation; and would undoubtedly have done so had his experiments continued a few days longer.

The time requisite to induce negative rotation may be curtailed by any agency whereby protoplasmic tone is lowered. Thus in a small piece of *Elodea* consisting of three or four leaf-whorls rotation is set up weeks earlier than in intact plants. The most rapid way of lowering the tone is by poisoning the protoplasm. It is therefore not a surprising circumstance that, if an *Elodea*-plant be placed in the dark in a weak solution of ferrous sulphate, rotation will supervene within forty-eight hours, and will continue until the death of the cells.

DESCRIPTION OF PLATE VII.

(With the exception of No. 4, the figures represent the objects seen by the aid of Hartnack's No. 7 objective, ocular No. 4, giving a magnification of 450 diameters; but the drawings are not strictly to scale.)

Figs. 1 & 2. Mesophyll cells of *Eschscholtzia californica* seedlings, seen from above: 1, in diffused light; 2, after remaining in darkness overnight.

Fig. 3. *Oxalis Acetosella.* Cell of mesophyll from leaf set in darkness for ten days, the large chlorophyll grains showing an evident tendency to apostrophe.

Fig. 4. From *Funaria hygrometrica.* Cell of a leaf from a plant which has remained a fortnight in very low light, the grains coming out from apostrophe to collect in the proximal end of the cell. The shaded grains came into view on further focussing: two of them (*p*, *p*) were in profile.

Figs. 5 *a* & *b*. Cells from the leaf-sheath of *Poa annua* twenty-two hours after its removal to darkness, mounted in water under a cover-slip meanwhile; the chlorophyll has collected to a greater or less extent round the nucleus.

Figs. 6 *a*, *b*, *c*. Massing of chlorophyll in a small piece of an *Elodea*-plant kept in the dark about ten days: *a*, fore-and-aft, *b*, corner, and *c*, nuclear arrangement.

Figs. 7 *a, b, c.* *Callitriche verna.* Leaf-cells from a plant deprived of light for ten days: *a*, from middle part of leaf, grains in simple negative apostrophe; *b* and *c*, from near their tip, the effect of darkness now more pronounced, the grains having massed.

Fig. 8. *Eschscholtzia californica.* Palisade-cells, seen from above after eleven days in the dark; the grains are closely massed.

Figs. 9 *a* & *b.* *Eschscholtzia californica.* Palisade-cells, in section, after twelve days' darkness; the right-hand cell of fig. 9 *b* is a mesophyll cell.

Fig. 10. Epidermal cell of the frond of *Pteris serrulata*, showing the effect upon the disposition of the chlorophyll of three weeks' withholding of light: *p*, a grain tilted up on to its edge by the pressure of its neighbours.

Figs. 11 *a, b, c.* A small portion of a prothallus of probably a species of *Adiantum*: *a*, grains moving into apostrophe under the influence of sunlight; *b*, commencing epistrophe after half an hour in the shade; *c*, epistrophe still further advanced, one of the grains in the left-hand cell still forced up into profile by its fellows.

Fig. 12. From a *Funaria hygrometrica* leaf set in sunlight, the grains making for the wall, which some have reached: *p*, a grain turned up on its edge after abutting on another already against the side-wall.

Fig. 13. Part of a barrel-shaped cell from the leaf of *Echeveria metallica* growing in low diffused light; two of the grains in the centre of the clump tilted up on to their edge.

Fig. 14. Top of cell of an *Elodea*-leaf with rotating protoplasm: *x*, grain about to change profile for broadside position.

Note on an Alga (*Dermatophyton radicans*, Peter) growing on the European Tortoise. By M. C. POTTER, M.A., F.L.S., Assistant Curator of the University Herbarium, Cambridge.

[Read 2nd June, 1887.]

(PLATE VIII.)

THE alga which is the subject of this paper is found growing principally upon the dorsal surface of the carapace of the water tortoise (*Clemmys caspica*), which inhabits the southern parts of Europe, and, by spending a great part of its existence in water, offers its back as a suitable nidus for algæ.

The alga appears to the naked eye as irregular but roundish dark-green patches which vary very much in size, often having a diameter of about a quarter of an inch, as at *a*, fig. 1, Pl. VIII. On removing a patch and cutting sections in a direction perpendicular to the animal's back, it is found to be composed of numerous rather large cells arranged very close together and generally square in shape. Some of these cells are exposed to the action of the water, and form a plate of cells a few layers thick, closely applied to the tortoise-shell, and others are found as wedge-shaped masses which penetrate into the shell. The cells of the plate whose free surface is exposed to the action of the water continually divide in directions perpendicular and parallel to the surface of the tortoise-shell; the outermost layer continually forms zoospores, and so prevents the plate from becoming more than a few cells thick. The cells next to the tortoise-shell are closely adpressed to it, and individually have the power of penetrating into any crack of the tortoise-shell which may present itself to them. When an algal cell meets with a crack, it strives to penetrate into it, in doing which it opens the crack more and more and so penetrates further in, and as it does so it divides first by a plane perpendicular to its direction of growth and then by planes perpendicular and parallel to this direction, and so forms wedge-shaped masses of cells, as at *a* in figs. 2 and 3, which grow and penetrate in any direction in which they can force open the crack. Sections cut parallel to the animal's back show on the outside masses of algal cells where the thick ends of wedges are cut through (*a*, fig. 3), and towards the centre sections of thinner parts of wedges (*b* and *c*, fig. 3). Thus a section through an algal patch similar to fig. 2, parallel to the animal's back, would be represented by a drawing resembling fig. 3.

If sections of the tortoise-shell and alga are allowed to remain in water for some few days, it is found that not only does the alga remain alive but continues to grow healthily. The cells exposed to the water continually form zoospores, while the layers in contact with the tortoise-shell, since the surrounding pressure is removed, tend to grow out into filaments (*a* and *b*, fig. 4). These filaments can be formed by any cells touching the tortoise-shell; they have a very irregular shape, and the chlorophyll is always situated at the growing end.

As before mentioned, the alga is reproduced by means of zoospores which are formed from the outermost layers of cells. The cell about to form a zoosporangium becomes flask-shaped, a kind of neck being formed, the contents of the cell dividing into a considerable number of zoospores, which have the usual pyriform shape and are all exactly alike; they swim about for a considerable time and then germinate. Sexual reproduction has as yet not been observed.

As regards the mode of life of the alga, from the fact that sections separated from the tortoise can be kept alive for a considerable time, during which the cells can grow and produce zoospores, it would seem that the alga derives no nourishment from the tortoise; yet the alga derives very great benefits from its mode of life, for the tortoise, though spending a great part of its time in water, is able to wander about from pool to pool, and thus conveying the alga with it, effects its distribution geographically. Again, during dry seasons, when a pool of water in which a tortoise infected with the alga becomes dried up, the tortoise is able to migrate to another, and generally does so at night, and hides in the shade during the day; in case it cannot find water in this way, the alga is kept alive by not being exposed to the heat of the sun. We must therefore at present regard the alga as an epiphyte, since at present the observations tend to show that no nourishment is derived from the tortoise.

At present, since the sexual reproduction of *Dermatophyton* is unknown, its proper place in the classification of the Algæ cannot be assigned; yet it evidently belongs to the *Chlorophyceæ*, and most likely to the *Ulvaceæ*, in the family Confervoideæ.

The alga described in this paper was first given to me by Professor Moseley, who had discovered it upon some tortoises and who desired me to work out its life-history. I was unable anywhere to find a description of it, and referred it to Professor Boret and to my friend Mr. George Murray, of the British Museum, with a similar result. I delayed to publish a description until I had found some mode of reproduction; and with this object in view I obtained a grant from the Worts Travelling Fund, and proceeded to Portugal in the summer of 1886. As soon as possible on my return, I read a paper before the Cambridge Philosophical Society, where I gave to it the name of *Epiclemmydia lusitanica* *. It was not until December 1886 that I found that Dr. Peter, of Munich, had published a mere description and had named the alga *Dermatophyton radicans* † on September 22nd of the same year.

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* Proceedings of Camb. Phil. Soc. vol. vi. pt. i. Nov. 8, 1886.

† Bot. Centralbl. Band xxviii. 1886, p. 125; SB. Versamml. deutsch. Naturf. u. Aerzte, Sept. 22, 1886.

DESCRIPTION OF PLATE VIII.

Fig. 1. Portion dorsal surface of carapace of *Clemmys caspica*, bearing numerous patches of alga (*a*, *a*).

Fig. 2. Section of tortoise-shell and alga in a direction perpendicular to animal's back; showing mode of penetration of alga (*a*) into carapace.

Fig. 3. Section of tortoise-shell and alga in direction parallel to animal's back; showing at *a*, *b*, *c* sections through wedges penetrating the tortoise-shell.

Fig. 4. Sections grown in water for some few days; showing at *a* and *b* the lowermost cells growing into filaments.

FUNGI JAPONICI NONNULLI: new Species of Japanese Fungi found parasitic on the Leaves of *Polygonum multiflorum*, Thunb., and *Lycium chinense*, Mill. By DR. CHARLES SPEGAZZINI and TOKUTARO ITO, F.L.S.

[Read 16th June, 1887.]

SOME years ago my attention was directed to the observation of the structure and life-history of some minute fungi which are found parasitic on the leaves of *Polygonum multiflorum*, Thunb., and *Lycium chinense*, Mill., growing abundantly not far from my residence in Tokio. The principal fungus infesting the former plant is *Puccinia polygonorum*, Schlechtd., which, according to Frank*, is already known to attack many species of *Polygonum*, such as *P. Convolvulus, dumetorum, lapathifolium*, and *amphibium* var. *terrestre*. Careful examination has, however, shown me that more than two species of fungi are parasitic on the leaves of *P. multiflorum*, Thunb., and that some of the fungi under my observation were as yet undescribed. Consequently I placed some of my specimens at the disposal of my valued correspondent, Prof. C. Spegazzini, an excellent observer of microscopic fungi, of the Colegia Provincia de la Plata, in the Argentine Republic, South America, for their systematic determination, which however was delayed, as the specimens arrived during his absence on a journey of scientific exploration among the wild Indian tribes of Patagonia. His letter, sent to me since his return to La Plata, contained interesting information of what he has made out from the dried specimens; from which it appears that of the three kinds of fungi found on *P. multiflorum*, Thunb., two have proved to be new, one of which Prof. Spegazzini proposed to call *Fusarium oidioide*, n. sp., while he has kindly honoured me by associating my name with the other, viz. *Phyllosticta Tokutaroi*, Speg. Moreover, the fungus found on *Lycium chinense*, Mill., forms a third new species, *Tuberculina japonica*, Speg. It may incidentally be added that all the specimens sent to Prof. Spegazzini were collected by me in the middle of October 1883; and thus, in the case of *Puccinia polygonorum*, Schlechtd., the stage of development represented is the *Uredo*-form. Since the microscopic fungi of Japan are as yet absolutely uninvestigated, I hope that the following short descriptions may not be without value in facilitating further researches on these plants.—[T. ITO.]

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* Frank, 'Krankheiten der Pflanzen,' 1880, p. 464.

1. UREDO POLYGONORUM, *DC. Fl. Fr.* p. 71. (Status stylosporicus *Pucciniæ polygonorum.*)

Obs. Stylosporæ ovoideæ (20–27 × 14–15 mill.), pallide fulvæ, laxe minusculeque muriculatæ, pedicello diffluente parvulo hyalino donatæ.

Hab. Ad folia viva *Polygoni multiflori*, Thunb., Tokio.

2. FUSARIUM OIDIOIDE, *Speg.*, nov. sp.

Diag. Maculæ nullæ; mycelium ephiphyllum, laxissime diffusum, subpulveraceum, indefinitum, album; hyphæ hyalinæ, repentes, dense ramosæ (3–4 mill. crass.), hinc inde ramulis irregulariter subfasciculatis, rarius solitariis, utrinque non v. vix attenuatis (5–10 × 4–5 mill.), apice truncatis, 2–3 sterigmatibus papillæformibus coronatis; conidia fusoidea, leniter falcata, 3–5-septata, non constricta, utrinque acuta, hyalina (30–50 × 3–4 mill.).

Hab. Ad folia viva *Polygoni multiflori*, Thunb., Tokio.

3. PHYLLOSTICTA TOKUTAROI, *Speg.*, nov. sp.

Diag. Maculæ sparsæ, solitariæ, irregulariter orbiculares, parvulæ (2–3 mill. diam.), centro pallescentes arescentes, areola sordide intenseque castanea, indefinita, latiuscula cinctæ. Perithecia pauca, prominulo-exerta, globuloso-depressa (250 mill. diam.), atra, glabra v. subpapillosa, ostiolo primo parum manifesto dein lacerodehiscente donata, coriacella contextu sinuoso-parenchymatico, olivaceo-atro, subpellucido. Sterigmata fasciculata, obclavato-elongata (25 × 1–2·5 mill.), hyalina, monospora, continua; stylosporæ ellipticæ v. ovoideæ, rectæ v. vix inæquilaterales (5–6 × 2–2·5 mill.), hyalinæ.

Hab. Ad folia viva *Polygoni multiflori*, Thunb., Tokio.

4. **Tuberculina japonica**, *Speg.*, nov. sp.

Diag. Cupulæ parvulæ, hemisphærico-applanatæ, subpulveraceæ, solitariæ, sordide fulvescentes (300–400 mill. diam.), areola parum incrassato-pulvinata, minuta, subfuscescente v. fulvescente insidentia; sporæ globosæ, crassiusculæ, tunicatæ, læves (7–8), fulvescenti-hyalinæ in sterigmatibus filiformibus subcoalescentibus (30–1·5 mill.) olivaceis acrogenæ.

Hab. Ad folia languida *Lycii chinensis*, Mill., Tokio.

On a further Collection of Ferns from West Borneo, made by the Bishop of Singapore and Sarawak. By J. G. Baker, F.R.S., F.L.S.

[Read 16th June, 1887.]

The present collection is supplementary to one on which I reported in Vol. xxii. of the Journal of the Linnean Society, pp. 222 to 232, pls. 11, 12. All the species were gathered in the Sarawak district, some by Dr. Hose himself and the others by his nephew, Mr. Charles Hose, and a few by Mr. Forstermann, a collector who visited Borneo in the spring of 1886. The numbers are Dr. Hose's collecting-numbers; those within brackets indicate the position of the new species in the sequence followed in our 'Synopsis Filicum.'

216. **Matonia sarmentosa**, n. sp.; sarmentosa, frondibus laxe pinnatis, pinnis 2–4-jugis linearibus simplicibus vel furcatis.

Niah, Sarawak, *Mr. Charles Hose.*

This is a very interesting novelty. It has precisely the fructification of *Matonia pectinata*, but is completely different in habit. The main rhachis of the frond is very slender and quite naked, like all the rest of the plant. The pinnæ are arranged on the rhachis generally in whorls of three or four at a distance from one another of 1½–2 inches, and are sessile and sometimes slightly confluent at the base. They are linear, from 2 to 4 inches long, simple or forked, obtuse, rigid in texture, ⅛ in. broad, with rather indistinct simple or forked free erecto-patent immersed veins. The sori are few in number, irregularly scattered over the back of the segments, with a flattened, mammillate, rigid, deciduous indusium, which falls away leaving a scar at the base of the stipe, and contains ten or a dozen sessile sporangia with a broad incomplete nearly vertical annulus.

175. TRICHOMANES DIGITATUM, *Sw.*

176, 177. T. FILICULA, *Bory.*

179 (4*). DAVALLIA (§HUMATA) PINNATIFIDA, n. sp.; rhizomate gracili firmo late repente, paleis lanceolatis castaneis, stipitibus segregatis strictis stramineis, frondibus lanceolatis simpliciter pinnatifidis rigide coriaceis glabris, pinnis brevibus linearibus obtusis crenatis, soris parvis submarginalibus, indusio semiorbiculari rigidulo.

Niah, Sarawak, *Mr. Charles Hose.*

Intermediate between *D. pectinata* and *D. pedata.* Rhizome slender, wiry, epigæous, with a few ascending paleæ. Stipes stiffly erect, 1½–3½ in. long. Fronds 3–5 in. long, broadest at the base (1½–2 in.), narrowed gradually from the base to the apex, cut down to a narrow wing into numerous crowded spreading primary segments, ⅛–¼ in. broad. Veins distinct, erecto-patent, simple or forked. Sori terminal on the veins, 8–10 on each side of the central and lower pinnæ. Indusium rigid, persistent, not more than ¼ line broad.

178. D. PEDATA, *Smith.*

189 (16*). D. (§ LEUCOSTEGIA) NEPHRODIOIDES, n. sp.; rhizomate late repente, paleis nigris piliformibus basi peltatis prædito, stipitibus elongatis nudis, frondibus magnis membranaceis oblongo-lanceolatis bipinnatifidis parce pilosis, pinnis lanceolatis subpetiolatis, pinnulis multijugis pectinato-pinnatifidis basi confluentibus, venis in pinnulis copiose pinnatis, soris medialibus, indusio parvo reniformi.

Niah, Sarawak, *Mr. Charles Hose.*

Nearly allied to the Javan *D. Kingii*, Baker, lately figured in Hooker's Icones, tab. 1622. Rhizome firm, epigæous, ⅛ in. in diam.; paleæ fine, hair-like, spreading. Stipe stiffly erect, ½ ft. long. Frond 2–3 ft. long, 8–9 in. broad at the middle, green, hairy mainly on the rhachides of the pinnæ, quite destitute of scales. Pinnæ subpetiolate, the central ones 4–5 in. long, 1–1¼ in. broad, the lower rather smaller, all except the lowest cuneate-truncate on the lower side at the base. Pinnules very numerous, oblique, oblongo-lanceolate, ⅛–⅙ in. broad, cut halfway down into close ascending lanceolate lobes. Veins one to each final lobe, with a small median sorus, with a glabrous reniform indusium.

102. DAVALLIA LOBBIANA, *Moore*. Sarawak. Gathered before once only.

185. D. SOLIDA, *Sw.* A curious form, excavated by some insect between the veins, so as to look at first sight like an *Asplenium*.

180. D. GRACILIS, *Blume*.

181. D. PALLIDA, *Mett.* (D. Beccariana, *Cesati*).

184. ASPLENIUM VULCANICUM, *Blume*. A form receding from the type in the direction of the Ceylonese *A. Wightianum*.

183. A. RESECTUM, *Smith*.

186. A. AFFINE, *Swartz*.

188. A. SCANDENS, *J. Smith*.

187 (231*). A. (§ DIPLAZIUM) CRINITUM, n. sp.; stipitibus robustis elongatis cum rhachidibus ubique paleis lanceolatis castaneis crispatis vestitis, frondibus membranaceis oblongo-lanceolatis bipinnatifidis vel bipinnatis, pinnis omnibus lanceolatis vel infimis oblongo-lanceolatis pinnatis, segmentis ultimis parallelis oblongis obtusis, venis copiose pinnatis venulis ascendentibus furcatis, soris costalibus ab segmentorum marginibus semper remotis.

Hab. Niah, Sarawak, *Mr. Charles Hose*.

The is the *Asplenium sorzogonense* var. *majus* of Hooker's Sp. Fil. vol. iii. p. 252, founded on a single specimen collected by Mr. Hugh Low. The lower pinnæ in Dr. Hose's plant are ½ ft. long, with largest pinnules 2 in. long and ⅝ in. broad. Besides being more compound than in typical *sorzogonense*, it differs by its crinite rhachis and stipe, and by the sori being confined to the inner half of the segments and not nearly so close nor so regular. The fully-developed oblong final segments are ¼–⅓ in. broad, and the lower veinlets are forked.

190. TRIPHLEBIA LONGIFOLIA, *Baker* (Scolopendrum longifolium, *Presl*). Niah, Sarawak, *Mr. Charles Hose*.

197. ASPIDIUM MEMBRANACEUM, *Hook.*

198. A. REPANDUM, *Willd.*

191. NEPHRODIUM CRASSIFOLIUM, *Hook.*

192. N. ARBUSCULA, *Desv.* A very large form.

193. N. MOLLE, *Desv.* A caudate subglabrous variety.

195. N. (§ SAGENIA) LOBBII, *Baker.* Sarawak. Only gathered previously by Lobb.

196 (207*). N. (§ SAGENIA) SUBDIGITATUM, n. sp.; stipitibus gracilibus dense cæspitosis nigro-castaneis, frondibus parvis deltoideis glabris subdigitatis, segmentis 5–7 lanceolatis acuminatis repandis vel subintegris, venis in areolis copiosis anastomosantibus, soris irregulariter sparsis, indusio firmulo persistente.

Hab. Niah, Sarawak, *Mr. Charles Hose.*

Allied to *N. Lobbii, subbipinnatum,* and *irriguum.* Caudex erect. Stipes densely tufted, 3–4 in. long, with a few spreading linear nearly black paleæ towards the base. Lower segment usually forked at the base; end segment the largest, distinctly stalked, about 3 in. long, ½ in. broad at the middle, deeply repand, narrowed gradually to the base and apex. Distinct main veinlets not present. Sori not very small.

174 (50*). POLYPODIUM (§PHEGOPTERIS) SUBARBOREUM, n. sp.; frondibus amplis deltoideis glabris bipinnatis, pinnis oblongolanceolatis, pinnulis lanceolatis, segmentis tertiariis oblongis obtusis crenatis, venis copiose pinnatis venulis furcatis, soris magnis medialibus biseriatis.

Hab. Niah, Sarawak, *Mr. Charles Hose.*

A very large plant, with naked polished light brown or stramineous rhachides. Pinnæ 1½ ft. long, 7–8 in. broad at the base. Pinnules 1–1½ in. broad. Tertiary segments sessile, ⅙–¼ in. broad, crenate, with copious ascending distinct forked veinlets and a long row of large sori midway between the midrib and margin. It is one of the largest and most compound of the known species of *Phegopteris.* In texture and in the size and shape of its final segments it resembles *N. Filix-mas,* var. *elongatum.*

199. P. VERRUCOSUM, *Wall.*

200. P. LABRUSCA, *Hook.*

212. P. LINGUA, *Sw.*

201. **POLYPODIUM LINGUÆFORME**, *Mett.*

204. **P. NIGRESCENS**, *Blume.*

202. **P. DIPTERIS**, *Blume.*

203 (352*). **P. (§DIPTERIS) QUINQUEFURCATUM**, n. sp.; rhizomate repente epigæo dense paleaceo, stipitibus strictis nudis validis elongatis, frondibus cuneatis rigide coriaceis 4–5-toties dichotomiter furcatis, segmentis lanceolatis acuminatis, areolis primariis quadratis, soris 2–6 minutis.

Hab. Builulu, *Mr. Forstermann.*

Allied to *P. bifurcatum*, but the frond four or five times dichotomously forked, with 18–20 lanceolate segments reaching a foot in length, above $\frac{1}{2}$ in. broad. Main veins erecto-patent, $\frac{1}{8}$–$\frac{1}{6}$ in. apart, prominently raised, connected much within the margin by a distinct cross-vein, each main areole thus formed containing usually 4–6 minute sori.

215 (50*). **GYMNOGRAMME (§CEROSORA) CHRYSOSORA**, n. sp.; rhizomate breviter repente, stipitibus contiguis elongatis castaneis nudis, frondibus parvis ovatis bipinnatis rigidulis glabris, segmentis ultimis obovato-cuneatis, sterilibus dorso nudis, venis flabellatis, soris copiosis confluentibus pulvere ceraceo aureo copioso intermixtis.

Hab. Builulu, Sarawak, *Mr. Forstermann*!

This appears to form a section connecting *Eugymnogramme* with *Ceropteris*, for although the barren fronds are quite naked beneath, the fertile ones have a copious golden waxy powder mixed with sori. The slender naked castaneous stipes reach a length of about 4 inches in the sterile and 6 in the fertile frond. The frond is 3–4 in. long, moderately firm and rather rigid in texture, turning brown when dried. The lowest pinnæ are much the largest and most compound. The cuneate acute or obtuse final segments are $\frac{1}{12}$–$\frac{1}{8}$ in. broad. The confluent sori cover nearly the whole breadth of the fertile segments, but do not reach the tip. In general habit it most recalls *G. leptophylla* and *chœrophylla*.

206. **G. INVOLUTA**, *Hook.*

205. **G. CARTILAGIDENS**, *Baker.* Banting, Sarawak. Only athered previously by Dr. Beccari.

207. **G. MACROPHYLLA**, *Hook.*

208 (71*). **Gymnogramme (§ Selliguea) campyloneuroides**, n. sp.; rhizomate late repente, stipitibus segregatis brevissimis, frondibus simplicibus oblongis rigidulis glabris cuspidatis ad basin longe attenuatis, venis primariis erecto-patentibus, venulis transversalibus primariis regulariter parallelis, soris in lineis interruptis inter venis primariis uniseriatis.

Hab. Sarawak.

Rhizome woody, $\frac{1}{8}$–$\frac{1}{6}$ in. in diam.; paleæ small, lanceolate, dark brown. Fronds 8–9 in. long, $2\frac{1}{2}$–$3\frac{1}{2}$ in. broad at the middle, narrowed very gradually to the base, moderately firm and rather rigid in texture, quite glabrous. Main veins very distinct, $\frac{1}{8}$–$\frac{1}{4}$ in. apart, regularly produced from the midrib to the margin, with distinct arching cross veins, enclosing each several areolæ with free included veinlets. Sori in single interrupted rows reaching all the way from the midrib to the margin. Allied to *G. membranacea* and *macrophylla*, Hook.

209. **Antrophyum reticulatum**, *Kaulf.*

194. **Acrostichum (§ Stenosemia) auritum**, *Sw.*

211. **A. flagelliferum**, *Wall.*

213. **A. aureum**, *L.*

210 (93*). **A. (§ Gymnopteris) oligodictyon**, n. sp.; rhizomate breviter repente, frondibus sterilibus lanceolatis rigidulis glabris stipitibus brevibus, venis pinnatis, venulis sæpissime bijugis valde ascendentibus infimis apice anastomosantibus, frondibus fertilibus linearibus, stipite elongato.

Hab. Niah, Sarawak, *Mr. Charles Hose.*

Stipes of sterile fronds 2–3 in. long, naked, pale brown. Sterile frond 8–9 in. long, $\frac{1}{2}$–$\frac{5}{8}$ in. broad at the middle, narrowed gradually to the base and apex, rather rigid in texture, quite naked. Veining of *Nephrodium*, only the lowest veinlets of the groups joining at the tip. Fertile frond linear, under $\frac{1}{4}$ in. broad, with a stipe 6–8 in. long. Habit of *Acrostichum simplex* or *lineare.*

214. **A. (§ Photinopteris) rigidum**, *Wall.*

On the Anatomy and Development of the Sporogonium of the Mosses. By J. REYNOLDS VAIZEY, B.A., St. Peter's Coll., Cambridge. (Communicated by S. H. VINES, F.L.S.)

[Read 20th January, 1887.]

(PLATES IX.–XII.)

I. POLYTRICHACEÆ.

i. INTRODUCTION.

THE work, of which this is the first instalment, was undertaken with the view of showing that the *Muscineæ* are not separated from the *Vasculares* (Pteridophyta and Phanerogamia) by so great a gap as has been usually supposed *.

The histology and morphology of the sporophyte † in the Muscineæ being almost unknown, it seemed that an investigation of that structure was highly desirable, and that it would serve to further elucidate the relations existing between the Muscineæ and other groups of plants. With this end in view these investigations were commenced.

The Polytrichaceæ were chosen as the starting point, as they are easily obtained, and their large size makes the examination of minute structure in them easier than in most of the other commoner Orders of the Musci. References, however, will be made to the structure of the sporophyte as found in other Orders and in some of the Hepaticæ. By referring to the structure of forms other than those of the Polytrichaceæ it becomes possible to distinguish the characters peculiar to that Order from those which are typical of the whole of the Musci.

A comparison of the structure of the sporophyte of the Musci with that of the Hepaticæ, and of both the Hepaticæ and Musci with the Vasculares, leads to certain speculations in regard to the phylogeny of these groups.

Before recounting my own observations, I have thought it desirable to give a brief outline of work which has already been done.

In 1782 *Hedwig* (8) ‡ gave the first account of the Musci which dealt with anything more than the external characters. He, I believe, was the first to show that the sporogonium was not an integral portion of the moss-plant, but grew as a separate organism attached to the oophyte in a way somewhat similar to that by which a parasite is attached to its host; he described also the intercellular space surrounding the spore-sac.

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* On this point *cf*. Goebel (5), p. 401, and Bower (2), pp. 604, 605.

† On the use of this term generally see Prof. Bayley Balfour's (1) note, in which he justifies its use and that of the corresponding term *oophyte*.

‡ The numbers in parentheses following the names of authors refer to the Bibliography on pp. 282, 283.

It remained, however, for an Englishman, *William Valentine* (27), to publish in 1833 the first account of the early development of the sporogonium. He also seems to have noticed that the tissues of the seta were differentiated into a cortical layer surrounding an axial cylinder, but he did not further investigate their respective characteristics. He describes the termination of the foot in two forms which he regards as exceptional, but which show a certain amount of similarity to what I have found among the Polytrichaceæ generally. Valentine describes the structure of the sporangium accurately.

In the same year that Valentine's work appeared in England, *Hugo von Mohl* (18) published an account of the anatomy and development of the spores of the Musci, and an account of the structure of the theca.

Lantzius Beninga (13) published in 1847 the result of his valuable work, which dealt exclusively with the theca, especial attention being paid to the peristome. He gave a description of the intercellular spaces and trabecular tissue found internally to the pore-sac in the higher Polytricha.

Hofmeister (9) in 1851 published a work on the higher Cryptogams, in which the Musci are dealt with. The earlier stages of development of the sporogonium are described, but the later only in the case of the theca and spores.

Lorentz (17) published in 1867 a fuller account of the anatomy of the Mosses than had ever before appeared; but his knowledge was only obtained from transverse sections of the organs and tissues with which he dealt. Some of his work is discussed below in detail. The chief result of Lorentz's work, so far as the sporogonium was concerned, was to show that there was a specialized axial cylinder of tissue which he called the "central strand." He also described the two forms of tissue of which the central strand consists, namely, a thick-walled hollow cylinder of tissue surrounding a solid axial cylinder of thin-walled cells.

ii. COMPARATIVE ACCOUNT OF THE MORPHOLOGY OF THE SPOROGONIUM OF THE MUSCI.

The Polytrichaceæ which, for the reasons mentioned above, were selected for special and detailed examination, were found to differ very greatly from all the other Musci in certain points of their structure; so much so that they seem to form a group by themselves. Hence, as far as possible, wherever the structure of the Polytricha under consideration differs materially from the other Musci, reference is made to species from other Orders, so that a more general view of the whole group may be obtained.

1. *External Morphology.*

The sporogonium of the Musci may be divided into three parts, namely, the *foot*, the *seta*, and the *theca*.

The term *foot* is applicable properly only to that portion which can be shown to be developed from the hypobasal cell; but for convenience, and as it has not yet been shown accurately how much is developed from the hypobasal cell, I shall call that part of the sporogonium the foot which is placed within the vaginula.

The *seta* is the portion of the sporogonium between the foot and the theca.

The term *theca* is applied to the apophysis together with the sporangium and its operculum &c. The theca is thus divided into two members.

The mature sporogonium has the tip of the foot turned upwards, as may be seen when it is pulled out of its sheath, or, better still, by means of a longitudinal section (Pl. IX. fig. 2, Pl. X. fig. 15). The angle where the true morphological apex is turned up will frequently be referred to as the apex of the foot, although it is evidently not the true morphologic apex. The epidermal cells of the seta are not parallel to the axis of the seta, but are, as in the stems of many vascular plants, spirally twisted.

In external morphology there is a considerable difference between the theca of the Polytrichaceæ, in those forms in which the apophysis is developed, and that of other Musci; in all those forms in which the apophysis is absent, the thecæ are similar. Among the Polytrichaceæ, the apophysis is absent in the genera *Atrichum* (*Catharinea*), *Oligotrichum*, and many *Pogonata*. In other Orders of the Musci, *e. g.* Splachnaceæ, Funariaceæ, Mniaceæ, Dicranaceæ, &c., there is an apophysis, but it is obviously a part of the theca; but in *Polytrichum* the apophysis is quite distinct, being separated from the sporangium by an annular constriction (Pl. IX. figs. 1, 3, 4, Pl. X. fig. 13). This constriction is often seen better if a longitudinal section of the theca is made, as it is not always evident from superficial examination. In *Polytrichum commune*, Linn., and *P. piliferum*, Schreb., it is more distinct, while in *P. formosum*, Hedw., and *P. juniperinum*, Hedw., it is less so *.

2. *Anatomy and Histology.*

ATRICHUM UNDULATUM, *Beauv.*

This form is covered by a distinct epidermis easily distinguished from the adjacent tissues, especially on the theca. *Atrichum* has no stomata; and, so far as I have been able to ascertain, stomata are only found on or in close connexion with the apophysis of those forms which possess that structure. Immediately beneath the epidermis of the seta there is a layer of thick-walled sclerotic cells, containing protoplasm, whose walls are of a brown colour, due, at any rate partially, to the presence of tannin, as is shown by the action of chromic acid. In the sterome of *Atrichum* there are no intercellular spaces (fig. 9). Passing inwards the cells become thinner-walled, and are separated by intercellular passages (Pl. XI. fig. 28, *cp.*, *i.*), as the cells of the cortical parenchyma of a typical Vascular Plant are; but these intercellular spaces are only found in the Polytrichaceæ, in other Orders they are absent (Pl. IX. fig. 10). This tissue, including the outer layer of sterome, may be conveniently called the cortex. Longitudinal sections show that the sterome is somewhat prosenchymatous, although some of the cells have nearly, and occasionally quite, horizontal transverse walls (Pl. X. fig. 14). The cells of the inner thinner-walled layer are rather peculiar in that they are arranged in filamentous strands; each strand is attached to the one above and the one below by a cell with one prosenchymatous end, but the other ends and the ends of the intermediate cells are horizontal (Pl. X. fig. 14). The cortical cells contain protoplasm and a well-defined nucleus with numbers of plastids (chloroplastids).

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* From drawings of those species of *Pogonatum* which I have not seen in which a rudimentary apophysis is present, the constriction appears to be present. In *P. alpinum*, Linn., this constriction, although present, is very slight.

In the centre of the cortex there is the strand of tissues (Pl. XI. fig. 28, *c.s.*), collectively called by Lorentz (17) the central strand. Unfortunately the term central strand has also been applied by Lorentz to a similar and analogous structure in the stem of the oophyte; but there is great anatomical difference between the central strand in the one generation and that in the other. With figs. 9 and 10 compare Lorentz (17), Taf. xxv. 83, *a*; Lorentz (16), Taf. iv. fig. 1; Unger (25), Taf. ii. 9 (*Dawsonia superba*), Taf. iii. 31.

The central strand is surrounded by a single layer of thin-walled cells (Pl. IX. fig. 11) similar to the cortical cells, except that they are on the average longer than the innermost of those cells (Pl. XI. fig. 28). These further resemble the cortical cells by containing starch-forming plastids, and so differ from the tissues of the central strand. This parenchymatous sheath constitutes the innermost layer of the cortex (exomeristem*), as will be shown below.

The central strand itself consists of certain tissues, which in the seta are characterized by the absence of intercellular spaces†; it contains two kinds of tissue. One of these forms a solid axial cylinder (Pl. XI. fig. 28, *a.c.*), called Leptoxylem‡; the other a hollow cylinder concentric with the former (Pl. XI. fig. 28, *o.c.*), called Leptophloëm.

The Leptoxylem consists of very thin-walled, much elongated prosenchymatous cells, whose cell-walls are, as far as can be made out, all that remain in the mature seta (Pl. IX. fig. 11). These cells do not contain any living protoplasm, but only here and there remnants of disorganized protoplasm. This conclusion has been come to after very careful examination and comparison of sections, both transverse and longitudinal, in which nothing more than a few granules, the last remains of the protoplasm of the meristematic cell, were found.

The Leptophloëm is a more extensive tissue-system than the leptoxylem, and it consists of thick-walled, considerably elongated cells (fig. 28, *o.c.*), forming in transverse section a zone two, rarely three or more, cells deep. The innermost cells of this layer are thicker than the more external. In longitudinal section (Pl. IX. fig. 11) the cells of this tissue show their peculiar form, being slightly dilated at one, and sometimes at both ends. In the latter case these cells may be described as being somewhat dumbbell-shaped. Their transverse walls are not usually horizontally placed, and in longitudinal optical section have often more or less the appearance of an elongated **S** (Pl. IX. fig. 11). These cells, although they contain granular protoplasm and a well-defined nucleus, do not contain any plastids; but they contain a number of granules which in many ways resemble those described by Janczewski (11) as occurring in the sieve-tubes of the Pteridophyta. These granules are stained yellow by (iodized zinc chloride) Schulze's solution, brownish-yellow by iodine, and bright blue with Hoffmann's blue. They appear in many ways quite distinct from protoplasm, and show no organization. These granules are also frequently found in the cortex, notably in that of *Dicranum scoparium*, Hedw., which contains a great number.

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* *Cf.* note, p. 276.

† I. e. Schizogenous intercellular spaces; lysigenous spaces sometimes occur in some of the Splachnaceæ; in *Splachnum sphæricum*, Linn. fil., there is a large lysigenous space in the centre of the leptoxylem.

‡ See for explanation of these terms, p. 275.

The cell-contents of the leptophloëm are generally found aggregated towards one or other end of the dumbbell-shaped cells, thus filling up the dilatation at that end (Pl. IX. fig. 11).

So far all attempts to demonstrate any protoplasmic communication between adjacent cells have been fruitless. Nevertheless some such communication, as has been shown to exist in the case of sieve-tubes by Sachs, and in the endosperm of seeds and parenchymatous tissues of the Vasculares by Gardiner (4), probably exists in the sporophyte of the Musci. Certain indications of an indirect nature are found in the more persistent clinging of the protoplasm to the transverse walls of elongated cells after the swelling-up of the cell-wall by Schulze's solution (Pl. IX. fig. 12). This observation in itself proves nothing; but the subject is worth further investigation.

Before leaving this subject it may be well to point out that there is no pitting or similar variation in the thickness of any of the cell-walls of the sporogonium, except in the case of the epidermis of some species of *Polytrichum* further described below.

The leptophloëm is stained a dull, rather faint blue by Schulze's solution, whereas the leptoxylem is stained a deep bright blue, which at once differentiates it from the former.

Passing upwards in *Atrichum*, the simplicity of its structure, due to the absence of an apophysis, makes the relation of the tissues in the seta to those in the theca easily intelligible. The epidermis is, of course, continuous from one to the other. The cortex of the theca consists immediately within the epidermis of a layer of close-celled parenchyma with a very few small intercellular spaces, which together with the epidermis forms the wall of the theca; internally to this there is a zone of trabecular tissue consisting of long parenchymatous cells, separated by very large intercellular spaces. This trabecular tissue connects the wall of the theca with the layer of cortical cells forming the outer wall of the spore-sac. The outer wall of the spore-sac consists of a layer of cortical cells two or three deep, without intercellular spaces derived from the exomeristem. Internally to the archesporium is the tissue of the columella, which consists of an outer layer of cubical parenchymatous cells, concentric with an inner axial strand of elongated parenchymatous cells. These two forms of tissue abut on one another without any cells of intermediate form.

Tracing the connexion of the tissues of the theca with those of the seta, the central strand of the seta is seen to correspond with those tissues of the columella which, according to Kienitz-Gerloff (12), are formed from the endothecium (my endomeristem[*]), namely the archesporium and all the tissues internal to it.

The most detailed account which has hitherto appeared of the anatomy of the seta of the Musci is the account given by Lorentz (17) of *Atrichum undulatum*; but he only studied transverse sections, so that his account is imperfect. He also seems to have been mistaken as to the connexion of the central strand with the cortex, for he states that it is only held in place by a single strand of cells, so that in transverse section it appears to be attached to the cortex by a single cell: with fig. 28 compare Lorentz (17), Taf. xxviii. 83. *θ*. This he accounts for by saying (although he gives no evidence for the statement) that some of the cells of the internal layers of the cortex are destroyed and absorbed, and that this result is partly arrived at by the growth in thickness of the seta. I have carefully examined setæ in all stages of development, but detected no sign of any such process, although the gradual separation of the cortical cells to form the intercellular air-passages was easily seen. It was indeed found, when the sections were made with due care, that in the mature seta every, or nearly every, cell of the parenchymatous sheath was connected with one or two of the cells of the cortex (fig. 28).

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[*] *Cf.* footnote on p. 277.

Examination of the cell-walls with the ordinary reagents showed that the cuticle of the epidermis contains cutin, and is covered by a distinct cuticle, which is isolated, but is not dissolved, by strong *chromic acid*; the cortical sterome was altered in some undetermined way, since Schulze's solution gave a slight purplish tint with only slight staining; neither aniline chloride, hydrochloric acid, nor phloroglucin produced any coloration*; the parenchymatous cells of the cortex showed a more distinct blue coloration with Schulze's solution. The cell-walls of the leptophloëm were only coloured very slightly dull light blue by Schulze's solution; aniline chloride, hydrochloric acid, and phloroglucin produced no coloration; the cell-walls of the leptoxylem with Schulze's solution stained a deep bright blue.

The above holds good for the species of *Polytrichum* and *Pogonatum* which I have examined, and for the species of Mosses from other Orders which I have been able to examine, e. g. *Funaria hygrometrica*, Linn., *Dicranum scoparium*, Hedw., *Mnium hornum*, Linn., &c.

POLYTRICHUM.

Several species of this genus have been used in this investigation, namely *P. formosum*, Hedw., *P. juniperinum*, Hedw., *P. piliferum*, Schreb., and *P. commune*, Linn.; so that all that is stated below in regard to this genus holds good for all those species except where the contrary appears. Several species of the genus *Pogonatum* have also been examined, but they do not differ materially from *Atrichum* and *Polytrichum*, being intermediate between these two genera.

The colour of the seta in the species of *Polytrichum* is due to the presence of red and brown colouring-matter in the cell-walls.

The structure of the seta in *Polytrichum* is fundamentally the same in this genus as in *Atrichum*. The variations from the type of *Atrichum* may be in part due to difference of size. The peripheral zone of cortical sterome is much deeper than in *Atrichum* (Pl. XI. figs. 28, 29, Pl. XII. fig. 47), being six or eight cells deep. These cells are sometimes, as in *P. formosum* (fig. 47), slightly separated by small intercellular spaces. It is probable that this is true generally, but it is difficult to make out, as, from the smallness of their size, very thin sections are required to show them.

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* Since writing the above, I have gone into the question of the constitution of the cell-walls in the Mosses more carefully, and, although the investigations are not yet complete, I am able to say that the cortical sterome is lignified and, perhaps, corky. The investigation is rendered peculiarly difficult owing to the presence of various colouring-matters in the cell-wall.

The cortical parenchyma is four to six cells deep, the cells being separated by very large intercellular spaces, so that the central strand appears in transverse section to be suspended by a number of chains (Pl. IX. fig. 29) from the cortical sclerenchyma.

The central strand is surrounded by a sheath similar to that in *Atrichum*. The leptophloëm is much more largely developed than in *Atrichum* (figs. 28, 29), being from four to six cells deep as against one or two; the innermost cells of the leptophloëm have a much smaller internal diameter than the more external ones, and are very much thicker-walled (figs. 29, 30). In consequence of this difference in thickness of the cell-walls there is an apparent separation of the tissue into two layers—an outer one, consisting of large (comparatively large) thin-walled cells, and an inner, consisting of thick-walled cells of small diameter. The leptoxylem consists, as in *Atrichum*, of a solid axial cylinder of thin-walled cells, sharply distinguished from the innermost thick-walled cells of the leptophloëm. The actual thickness of these cell-walls is rather greater than in *Atrichum*, and instead of their internal diameter being on the whole smaller than that of the adjacent leptophloëm-cells, it is greater. The leptophloëm has the same structure in other points as in *Atrichum*, containing protoplasm and nucleus. The prosenchymatous ends of the leptoxylem-cells are best seen in transverse sections, stained with either hæmatoxylin, Schulze's solution, or methylene blue.

In *Polytrichum*, as mentioned above, the *theca* is differentiated into two organs, namely, the sporangium and the apophysis. The sporangium has in this genus a more complicated structure than in the rest of the Order, being of prismatic form with from four to six sides. The apophysis has the form of a flattened bilaterally symmetrical spheroid (Pl. IX. figs. 1, 3, 4), attached by one pole to the seta, and by the other to the sporangium, in *P. piliferum* and *P. commune*. The exact form of the apophysis can be best understood by a reference to the figures showing views of the whole theca (Pl. IX. figs. 1, 3, 4), and comparing them with the sections (Pl. IX. fig. 9, Pl. X. fig. 13). *P. formosum* and *P. juniperinum* have an apophysis of symmetric hemispherical form (Pl. IX. fig. 5).

The stomata are placed in a band in the annular depression or constriction separating the apophysis from the theca.

The anatomy of the sporangium has been fully described by Lantzius Beninga (13), so there is only one point upon which I have made observations that need be mentioned. In *Polytrichum commune*, and perhaps in some other species, the epidermis was seen, upon a surface-view, to have a peculiar papillary appearance (Pl. XII. fig. 49). Sections vertical to the surface showed the cause of this: each epidermal cell rises at the middle point of its external surface, so as to form an outward projection from each cell, and from the cell-lumen a deep pit penetrates into this papilla, leaving the tip of the papilla only closed by a very thin membrane (fig. 48).

This is the only pitting of any sort to be found throughout the moss-sporogonium, unless the thin parts of the cell-walls left between the thickenings of the teeth of the peristome be looked upon as pits. This peculiar modification of the epidermis is only found on the wall of the sporangium, and as that is the part covered by the calyptra it has occurred to me that a possible explanation of this structure is, that by means of these modified pits nourishment may be conveyed from the epidermal cells of the sporogonium to the calyptra.

The apophysis is covered by a cuticularized epidermis, with a distinct cuticle, in which, in a definite region, the stomata are developed. These stomata, as Schimper (22) (23) pointed out, are peculiar in that the stoma is guarded by what may, from one point of view, be regarded as a single guard-cell; for the cellulose plate separating the two cells is never completed to meet the side-walls of the mother-cell, thus leaving a passage at each end of the cellulose plate by means of which the cavities of the guard-cells communicate. There is, however, a nucleus on each side of the cellulose plate, which splits to form the stoma (Pl. X. fig. 17). The relations of the guard-cells are also shown in Pl. X. figs. 20–23, which show sections taken through the stoma at various points.

My observations also confirm Haberlandt's (6) in regard to the peculiar form of the lips of the stomata of *Polytrichum* (Pl. X. figs. 18, 20); compare also Haberlandt (6), Taf. xxvi. The stomata of other Musci are, in those forms in which they are known, according to Haberlandt's and my own observations, similar to the stomata of the higher plants (Pl. X. fig. 27). Stomata have been seen in all stages of development; and these observations show that the cell-plate is at no period complete in *Polytrichum*. This form of stoma is found also in *Funaria* (Pl. X. fig. 19) and in some Angiospermatous Phanerogams, e. g. *Protea* sp., according to H. von Mohl (19). In all other forms in which the stomata have been observed, they have the normal form found in vascular plants.

In the Antherocerotеæ—the one Order of the Hepaticæ which have stomata on the sporogonium—I have found them to be of the typical vascular form (Pl. X. fig. 24, 25); also in the following Musci:—*Mnium hornum*, Hedw. (Pl. X. figs. 26, 27), *Dicranum scoparium*, Hedw., and *Splachnum vasculosum*, Linn. (fig. 29); and *Phascum cuspidatum*, Schreb., according to Kienitz-Gerloff (12)*.

Underneath the epidermis of the apophysis the cortical tissue of the sporogonium is much more strongly developed; in fact, nearly the whole of the extent to which the apophysis exceeds the diameter of the seta is due to increase in cortical parenchyma. The cells of this tissue are here closely packed, only leaving small intercellular spaces, except immediately under the stomata, where large intercellular air-passages are found (Pl. IX. fig. 9; Pl. X. figs. 13, 18, 20–23). In transverse section the cortical parenchyma is seen to be arranged in rows of cells radiating from the "central strand" to the epidermis. These cells are elongated in a radial direction (Pl. IX. fig. 9). Their exact arrangement can be best understood by comparing the transverse (fig. 9) with the longitudinal section (Pl. X. fig. 13). The cell-walls are for the most part thin, except those just underneath the epidermis (Pl. X. fig. 18), which are slightly thickened.

In transverse as well as in longitudinal section the development of a bilateral symmetry is evident (Pl. IX. fig. 9, Pl. X. fig. 13). In transverse section the "central strand" is seen to occupy a position much nearer to the posterior side of the apophysis than to the anterior, and equidistant from the two flanks. The cortical tissue of the apophysis in *Polytrichum* differs from what is more usually found in possessing so few and such small intercellular spaces. In most other forms the development of intercellular passages is very large; and in *Splachnum vasculosum* the cortical tissue of the apophysis is very similar to the trabecular tissue surrounding the spore-sac of the Musci generally.

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* To this list may be added *Mnium cuspidatum*, Hedw., *Splachnum ampullaceum*, Linn., and some others more or less modified, according to Haberlandt (6).

In the apophysis of *Polytrichum formosum* the central strand is reduced, and loses some of its distinctive characters. The cells become less elongated and more isodiametric in the upper parts of the apophysis, and the tissues are no longer distinguishable into leptoxylem and leptophloëm, as protoplasm is found in all the cells.

In the more highly differentiated apophyses of *P. piliferum* and *P. commune* the central strand retains its characters, although they are gradually lost in the stalk connecting the apophysis with the sporangium; the leptoxylem is more largely developed than in the seta, and, as seen in transverse section, the leptophloëm does not form quite so deep a zone round it nor are its limits distinctly defined (Pl. IX. fig. 9).

The lower end of the sporogonium, which is inserted into the stem of the oophyte of the moss, is called the *Foot*. Its structure is interesting on account of its physiological importance as the organ by means of which the absorption of liquids takes place. All the water, with the substances in solution required for the nourishment and transpiration of the sporogonium, must be taken up by the foot. From the size and complexity of the organs of the sporogonium and from the number of the stomata, it is obvious that these processes must be very active.

The foot is from $\frac{1}{4}$ to $\frac{3}{8}$ inch in length; it tapers downwards, and the tip is, as has been mentioned, turned up (Pl. IX. fig. 2). A careful examination of both transverse and longitudinal sections shows that the foot has pushed its way into the tissues of the stem of the oophyte. This is apparently effected by the cells of the young calyptra becoming hard and thick-walled before it is separated from the vaginula*. Consequently, when the young sporogonium grows in length, the calyptra for some time prevents it from pushing upwards its upward-growing apex, so that the lower apex is forced down into the stem of the oophyte through the softer to the harder tissues, when the pressure on the calyptra becomes so great that it is torn away from the vaginula. By the foot being forced down in this way into the centre of the conducting tissues of the oophyte, a supply of food-material is assured to the foot. Transverse sections of the foot, with the surrounding tissue of the oophyte, show that the cells of the tissues of both structures, especially in the regions where they are in contact with one another, are gorged with protoplasm, and have large well-defined nuclei and nucleoli. Longitudinal sections of material carefully prepared by hardening in absolute alcohol or 1-per-cent. chromic acid, and afterwards treated with alcohol, show the protoplasm of the cells in a highly granular condition with a striated, almost stringy or ropy, appearance, giving the impression that active circulation or rotation of the protoplasm was going on in the tissue while in a living condition. The striations are usually slightly diagonal, but nearly parallel to the long axis of the seta. Transverse sections show that the foot has essentially the same structure as the seta, and, near its point of junction with the seta, is identical. A series of sections shows that, passing downwards, the leptophloëm gradually diminishes, and that the leptoxylem, which, as in the seta, is totally devoid of protoplasm, increases.

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* According to Hy (10) the cell-walls of the archegonium (future calyptra) are strongly thickened after the fertilization of the ovum (oosphere).

The cell-walls of the tissues of the foot are totally without colouring-matter—even the cortical sterome, which also is less sclerotic. The cortical parenchyma-cells are almost cubical in form, and are thicker-walled than in the seta.

A median longitudinal section of the foot (Pl. X. fig. 15, Pl. XI. fig. 31) shows the change that takes place in the tissues of the central strand; the leptophloëm is gradually reduced, so that at a short distance from the apex, instead of forming, in *Polytrichum*, a zone five or six cells deep, it is reduced to two, the innermost cells of this layer, apparently taking on the functions and form of the leptoxylem, losing their protoplasmic contents. This process goes on till the whole of the central strand is transformed into a thin-walled prosenchyma without protoplasm (fig. 31). The cortical tissues of the apex undergo a similar change, and the intercellular spaces are lost a little above the apex. The epidermis retains its protoplasm. The apex of the foot consists solely of this thin-walled parenchyma and some disorganized cells (fig. 31).

3. *Note on the Nomenclature of the Central Strand.*

A paper has recently appeared by Haberlandt (7) on the anatomy and physiology of Mosses. In regard to what he has said about the sporophore, I think it will be useful to make a few remarks.

On the whole, Prof. Haberlandt's observations and my own are in agreement; but he does not seem in all cases to have determined the limits of the outer cylinder and the parenchymatous sheath.

Prof. Haberlandt has called the tissues of the central strand of the seta by the same names that he has given to the several parts of the vascular bundle in the Vascular Plants; namely, the axial solid cylinder of thin-walled cells the Hadrom strand, and the outer hollow cylinder the Leptom cylinder. The terms Hadrom and Leptom were first used by Haberlandt (7) in 1884 to designate the wood (xylem) and bast (phloëm) of the Vascular Plants; and there would have been no objection in so using them for the tissues of the central strand of the seta (sporophyte) so long as they were not used also for the conducting tissues of the oophyte; but unfortunately Haberlandt has used them for both purposes, so that henceforth these terms cannot be applied so as to to have a strictly morphological meaning. Consequently, although it had not originally been my intention to do so, I thought it best to adopt some terms for the tissues which I have described above which should have a fixed and definite morphological meaning. As every one will admit that the tissues of the sporophyte of the Muscineæ are homologous with those of the sporophyte of the Vasculares, even if they also consider them to be homologous with other structures, the terms Leptoxylem and Leptophloëm have been adopted to designate the water-conducting * and organic-material-conducting tissues respectively of the sporophyte only of the Muscineæ.

The prefix *lepto* (λεπτὸς, meaning ***thin, slender, insignificant***) has been used for scientific purposes to indicate rudimentariness of structure in, for example, the name "***Leptocardia,***" † and again in

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* On the function of this tissue see my note on the subject elsewhere (26).

† *Leptocardia*, a class of the Chordata in the Animal Kingdom, partly characterized by having a very rudimentary heart.

"*Leptosporangiata*"*. The parenchymatous sheath may be called the endodermis, as Prof. Haberlandt calls it by the German equivalent Schutzscheide.

The term Leptoxylem will then be used to designate the water-conducting tissue only of the sporophyte of the Muscineæ; and Leptophloëm to designate the tissue only of the sporophyte of the Muscineæ which has the same function as the bast in the Vasculares.

So that the homologies between the sporophyte of the Musci and the sporophyte of the Vasculares may be thus tabulated:—

MUSCINEÆ.		VASCULARES.
Sporophyte.		*Sporophyte.*
Epidermis	=	Epidermis.
Cortex	=	Cortex.
Endodermis	=	Endodermis.
Central strand, product of endomeristem	=	Axial vascular bundle or system of bundles.
Leptophloëm	=	*Phloëm.*
Functional bast.		Functional bast.
Leptoxylem	=	*Xylem.*
Functional wood.		Functional wood.

iii. DEVELOPMENT OF THE SPOROGONIUM.

The earliest stages of development, from the first division of the oospore to the formation of a fusiform embryo, and the later development of the spore-sac and theca, have been described by Kienitz-Gerloff (12) and Hofmeister (9) more or less completely. Therefore the development between these two stages only has been investigated for the purposes of this paper.

According to Kienitz-Gerloff (12), the young embryo of *Atrichum undulatum* grows in length by means of a two-sided apical cell; so that two series of semicircular segments are formed. Each segment is then divided by a radial wall into two approximately equal parts. These walls are known as the quadrant- and octant-walls, the first formed being the quadrant-wall; those next formed at right angles to the quadrant-wall are the octant-walls. In transverse section, therefore, the circular outline of the sporogonium appears to be divided into four nearly equal sectors. Each quadrant at a later period, or lower down on the embryo, is divided into three cells in such a way that there are two cells at the periphery and one at the centre (Pl. XII. figs. 41, 42); so that there are four cells at the centre surrounded by eight cells. The exterior eight cells form the amphithecium of the theca (my exomeristem), the four cells at the centre the endothecium (my endomeristem). This method of development is so far just the same for either the theca or seta.

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* *Leptosporangiata*, a class of Ferns. The force of *lepto* in this word is, I should think, a little doubtful.

The terms exomeristem and endomeristem, first used by Russow (20) and Sanio (21), have been adopted by me in a slightly modified and restricted sense*. At the stage just described it will be seen that there are two sets of cells—the four central and the eight peripheral ones. Each of these sets henceforth grows according to a distinct and different law. The four central cells and the meristem which they give rise to I have called the endomeristem; and the eight peripheral cells and the meristem to which they give rise I have called the exomeristem.

From the point just described above, I have observed the development of the seta continuously up to the time when the theca begins to be formed. The development of the seta is acropetal; so that a series of sections taken below one another illustrate the methods of development of the several tissues.

The next stage of development shows that each of the exomeristem-cells has been divided tangentially by a radial wall; so that the exomeristem consists of sixteen cells (fig. 35). So far, no divisions have appeared in the endomeristem. A little below the point shown in fig. 35 a ring of tangential walls appears in the exomeristem, which has therefore now become two-layered. At the same time more radial walls appear in the exomeristem (figs. 32, 33, 34). By the time this stage is reached, divisions make their appearance in the endomeristem in a growing point that is giving rise to the seta; although, if the sections are made through a young theca, it will be found that the endomeristem has not yet begun to divide any further. In the former case, at a stage a little later than that shown at fig. 32, division will have begun in the endomeristem, as shown by fig. 36, where walls are formed dividing the endomeristematic mother-cell of each quadrant into two. The wall is in each case at right angles to either one of the octant- or quadrant-walls and parallel to the other quadrant- or octant-wall, as the case may be (fig. 36). A little later, in each of the cells thus formed another wall is formed at right angles to the one immediately preceding it and parallel to the one before that (fig. 37); each of these cells is again divided by walls again at right angles to the wall immediately preceding it and parallel to the one before that (fig. 38). This process then continues, so that the endomeristem consists of a number of cells which in transverse section have a rectangular outline.

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* Russow's terms exomeristem and endomeristem have been adopted and applied to the meristems of the sporophyte of the Moss, because it seemed, on the one hand, that it would be a mistake to invent new ones; and, on the other, the tissues produced in the case of the Moss from its two meristems are homologous with the tissues produced from the two meristems in the Vasculares in those cases, at any rate, in which the vascular system is axial. Therefore I have called the meristem which produces the central strand the endomeristem; and the meristem which produces all the tissues outside the central strand, namely the epidermis and cortex, the exomeristem. Russow's use of the terms in regard to the Lycopodiaceæ is that nearest to the use which I have here ventured to make.

The law stated above for the divisions in the endomeristem holds good, I believe, so long as divisions go on in that tissue; but beyond a certain point it becomes difficult to follow. Meanwhile, growth has been going on in the exomeristem, where divisions take place according to a different law to that obtaining in the endomeristem, in consequence of which the endomeristem is at once easily distinguished. In the exomeristem divisions take place in such a way that the cells are arranged in radial rows, and the radial walls are more numerous towards the periphery. After a time growth in the internal layers ceases, being carried on in the peripheral portions almost exclusively At a very early stage the formation of tangential walls ceases absolutely in the innermost cells of the exomeristem.

The best way of explaining the mode of development of the exomeristem is to follow the divisions of one of its peripheral cells and of the cells arising from that one. A comparison of such cells at different stages of their development will show that the cell is divided first radially by a tangential wall into two cells, one central, the other peripheral in position. The peripheral cell is then divided tangentially by a radial wall, and then each cell so formed is divided by a tangential wall, thus forming two radial rows. In the peripheral cells of each of the rows, either a tangential or a radial wall may be formed or a number of tangential walls; radial walls do not appear as frequently as tangential walls, and never two in succession. Divisions, both tangential and radial, appear in the peripheral, not in the central cells of a series. I think it extremely probable that, at any rate, radial walls are formed only in the most peripheral cells, that is only in the external layer of cells of the sporogonium. A reference to Pl. XII. figs. 37–40, will make the account of the development of the exomeristem clear.

From the fact of divisions taking place as just described, it is easy to see in a transverse section from which cell in the central part of the exomeristem several radial rows are derived, since cell-division takes place much as in the cork cambium of the Phanerogamia; in transverse section the cells of the exomeristem are not rectangular, for of the tangential walls the peripheral is greater than the more central (figs. 37, 38, 39, 40). At about the stage represented in fig. 39 intercellular spaces are beginning to be formed between the innermost cells of the exomeristem.

In the development of the growing-point, I may briefly refer to the order in which the radial walls are formed at the growing-point of the sporophyte of the Muscineæ and of the lower Pteridophyta. A reference to Pl. XII. figs. 44, 45, 46—representing transverse sections through the growing-point of the sporophyte of one of the Hepaticæ, one of the Musci, and of *Equisetum*—makes it evident that the principle, according to which at any rate the earliest divisions appear, is the same in each case; although in *Equisetum* there is a complication arising from the fact that the apical cell is three-sided, and not two-sided as in the Muscineæ.

It is in the seta only that the small-celled tissue, formed by the frequent divisions taking place in the endomeristem, gives rise to the structure known as the central strand. The sheath of the central strand consists of the innermost layer of cells of the exomeristem (figs. 41, 42). At a stage somewhat later than that shown by fig. 42, the tissue of the endomeristem begins to be distinguishable into an outer zone of thick-walled cells containing a quantity of protoplasm, while the axial strands of cells do not increase in thickness, and the quantity of protoplasm diminishes.

With regard to the respective methods of cell-division and growth in the exomeristem and endomeristem, the exomeristem grows from a peripheral zone, so that the cells at the periphery are the youngest; and as the cells at the centre cease dividing, they may be looked upon as the oldest. Therefore the sheath or endodermis of the central strand consists of the oldest cells of the exomeristem. The endomeristem differs from the exomeristem by dividing equally throughout in any transverse plane, so that all the cells in a given plane are of the same age. The epidermis in the sporogonium is not derived from any special layer or meristem, but is only the most external layer of cells of the exomeristem.

Figs. 6, 7, 8 *a–d*, represent the external morphology at various stages, from the youngest I have been able to obtain (a small fusiform embryo) to the nearly mature sporogonium with fully developed theca. At the earliest period the embryo grows by means of an apical cell (fig. 32); but from the stage represented by fig. 6 *b*, or very shortly after, the apical cell is divided up into several cells, and growth in length is no longer continued by new segments being cut off from an apical cell. At a certain period after this stage is reached, the formation of the theca commences (fig. 8 *a*); this is seen in the slight swelling which appears a little below the apex. This swelling is greatest at its most distant point from the apex, forming first what will eventually become the apophysis. At a later period the upper part swells, and develops further to form the sporangium.

About this time—the stage shown in fig. 8 *b*—the young stomata begin to be formed. They are formed by given cells at the surface ceasing to divide, but continuing to increase in size at the same rate as the surrounding cells, thus forming mother-cells for stomata, which are about eight times the size of the surrounding superficial cells. The nucleus of the mother-cell divides tangentially, and a radial wall is formed between the two daughter-nuclei, connecting the external peripheral wall with the internal central wall of the mother-cell by a plate of cellulose. It, however, does not extend to any of the other walls of the cell*. At a later period this cell-plate splits, thus forming the opening of the stoma. Both the nuclei remain, and can be seen throughout the life of the sporogonium.

It is found that in the theca the endomeristem is more largely developed in proportion to the exomeristem than in the seta. Compare figs. 43 and 40.

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* In *Funaria*, according to Haberlandt (6), the development of the stoma is different, and there is in that form a stage at which the two guard-cells are completely separated, parts of the cell-wall separating them being dissolved subsequently.

iv. CONCLUSION.

I may summarize as follows:—

1. That the tissues of the central strand in the cases investigated consist of two kinds of tissue—the leptophloëm, whose function is inferred on anatomical grounds (detailed in i. 2) to be similar to that of the phloëm of Vascular Plants; and the leptoxylem, the function of which I originally inferred on anatomical grounds, but have lately (26), by direct experiment, determined to be that of conducting the transpiration current up the seta.

2. That the apophysis of the Moss sporogonium is an organ for absorbing and assimilating gases, and that transpiration takes place from it must be fairly evident from the account of its anatomy given above, and it is in this respect similar to the leaves of the Vascular Plants. Its morphological value I cannot now discuss, but I hope shortly to be able to do so fully.

Although, as I have pointed out above, the stoma of the Polytrichaceæ differs from what is typical in the Muscineæ, it is only a modification of that form, and does not differ in essential points. The stomata of the sporophyte of the Muscineæ generally belong to the same type as those of the Vasculares (see Pl. X.).

Leitgeb (15) has shown that the so-called stomata of the oophyte of the Marchantiaceæ are essentially different from the true stomata of the sporophyte of the Muscineæ and Vascular plants.

3. The foot is the organ of absorption of liquids, although it does not present the ordinary form of a root, as it does not show, so far as I have been able to determine, any sign of endogenous growth. The root of *Phylloglossum*, which, according to Bower (3), is not endogenous in origin, may perhaps form a connecting-link between the foot of the Muscineæ and the root of the *Vasculares*. From the fact of the parasitic habit of the sporophyte of the Muscineæ, the absence of a root-cap is hardly surprising, as that organ is lost in many parasitic plants altogether; and in those in which it is present in the embryonic primary root, e. g. *Viscum*, it is lost, according to Solms-Laubach (24), when the young plant begins to grow parasitically into the tissues of the host.

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DESCRIPTION OF THE PLATES.

PLATE IX.

Fig. 1. General view of theca of *Polytrichum commune*, with a portion of the seta. *S.*=seta; *ap.*=apophysis; *st.*=region upon which the stomata are developed; *sp.*=sporangium; *pt.*=annulus; *L.*=lid.

2. The foot of the sporogonium of *P. commune*. *v.*=vaginula; *ft.*=foot; *S.*=seta.

3. 4. *P. commune*. Letters as for fig. 1. *b*=left side or angle; *r*=right side; *p*=posterior side; *a*=anterior side.

5. *P. formosum*. Letters as for fig. 1.

6. Letters the same as in figs. 1 and 2. Various stages of development of the sporogonium of *P. formosum* from (*a*) the youngest to (*c*), in which the rudiments of all the parts can be made out.

7. Young sporogonium of stage of fig. 6 (*a*), × about 11.

8. Young thecæ of *P. formosum*. Letters as in fig. 1.
   a. The young theca is just visible,=stage figured by fig. 6 *c*.
   b. At this stage the position and limits of the lid can be seen. The apophysis cannot yet be distinguished from the sporangium.
   c. Rather later stage than *b*. The apophysis is being formed. At this stage the young stomata are forming, but are not yet open.
   d. Nearly mature theca. The angles have not yet been formed; a section through the theca at this stage is nearly circular.

9. Transverse section through the apophysis of *P. commune*, ×40. *ep.*=epidermis; *c.*=cortex; *c.s.*=central strand, the limits of which are not clear in this region.

10. Transverse section of the seta of *Funaria*, a form in which there are no intercellular spaces in the cortex of the seta. Letters as in fig. 9.

11. Longitudinal section of the seta of *Atrichum undulatum*, ×300. *ep.*=epidermis; *c.*=cortex; *i.*=intercellular spaces; *c.s.*=central strand; *sh.*=parenchymatous sheath of *c.s.*; *oc.*=leptophloëm; *ac.*=leptoxylem.

12. Cells of the cortex of *Atrichum undulatum* (longitudinal section) stained with Hoffmann's blue and treated with Schulze's solution. *p.*=protoplasm of cell; *sc.*=swollen cell-wall; *md.*=middle lamella; *n.*=cell-nucleus.

PLATE X.

Fig. 13. Longitudinal section through the apophysis of *Polytrichum commune*. *a.*=anterior side; *p.*=posterior side; *th.*=base of the theca; *ep.*=epidermis; *st.*=stomata; *c.*=cortex; *c.s.*=central strand.

14. Longitudinal tangential section (a portion only) of *Atrichum undulatum*, to show the arrangement of the cortical filaments, every fourth or fifth cell having a prosenchymatous end.

15. Longitudinal section of the foot of *Polytrichum commune*, diagrammatic. *c.*=cortex; *oc.*=leptophloëm; *ac.*=leptoxylem; *cs.*=central strand; *wo.*=water-absorbing organ; *ta.*=turned-up true morphological apex of the foot; *a*=point frequently referred to as apex of foot.

16. Stoma of hypophysis of *Splachnum vasculosum*.

17. Surface view of stoma of *P. formosum*. The nuclei in the cells are shown.

18. Vertical section through the stoma of *P. formosum*.

19. Stoma from hypophysis of *Funaria*.

20.–23. A series of sections vertical to the stoma of *P. commune*, to show the communication of the two guard-cells. *st.*=opening of the stoma; *g.*=guard-cell; *i.*=intercellular air-passages; *c.*=cortex.

24., 25. Stomata from the sporogonium of *Anthoceros*.

26. Stoma of *Mnium hornum*.

27. Vertical section through 25.

PLATE XI.

Fig. 28. Transverse section of the seta of *Atrichum undulatum*, ×300. *ep.*=epidermis; *i.*=intercellular spaces in the cortex; *c.sl.*=cortical sclerenchyma; *c.p.*=cortical parenchyma; *sh.*=parenchymatous sheath of the "central strand"; *o.c.*=leptophloëm cylinder of the "central strand"; *ac.*=axial cylinder of leptoxylem of ditto.

29. Transverse section of the seta of *Polytrichum juniperinum*, ×300. Letters as in fig. 28.

30. Transverse section of the central strand of *P. juniperinum*, ×520. Letters as in fig. 28.

31. Longitudinal section of apex of foot of *P. formosum*, ×320. *d*, mass of disorganized cells at end of the foot. These cells are so much displaced and broken that it is impossible to draw them accurately. Other letters as in fig. 15.

PLATE XII.

Fig. 32. Longitudinal optical section through the young growing point of sporogonium of *P. formosum* at stage *a*, fig. 6.

Figs. 33 to 43 inclusive from sections cut after imbedding in paraffin with Caldwell-Threlfall microtome.

33.
34.
35.
36.

A series. Fig. 33, nearest the apex; fig. 36, furthest off, together with fig. 41.

Transverse sections just below apex of sporogonium at that stage in which a theca is going to be formed.

O.=octant-walls; *Q.*=quadrant-walls; *ex.*=exomeristem; *end.*=endomeristem; *sh.*=sheath; *c.s.*=central strand.

Fig. 33, *Atrichum undulatum*, after Kienitz-Gerloff. The others from *Polytrichum formosum.*

37.
38.
39.
40.
41.
42.

Transverse sections through the young growing apex of *P. juniperinum.*

These with fig. 33 form a series illustrating the development of the seta. Letters as in figs. 33 to 36.

In fig. 39 the small numerals indicate the order in which the walls are formed.

43. See under fig. 33 above. Section through base of young theca of *P. formosum.* Letters as in figs. 33–42.

44. Diagram to illustrate the primary division into (*exo.*) exomeristem and (*end.*) endomeristem in a moss sporogonium. *Q.*=quadrant-walls; *O.*=octant-walls.

45. Transverse section of young embryo of ***Frullania dilatata*** for comparison with fig. 44. After Leitgeb (14).

46. Transverse section of young stem of ***Equisetum*** for comparison with figs. 44 and 45.

47. Transverse section through the cortex of *Polytrichum formosum*, ×520. (Cut after imbedding in paraffin with Caldwell-Threlfall microtome.) *ep.*=epidermis (this shows the cuticularized outer wall); *scl.*=cortical sclerenchyma; *m.l.*=middle lamella; *i.*=intercellular spaces.

48. Vertical section through the wall of the theca of *P. commune*, to show the peculiar pitting of the epidermal cells.

49. Surface view of epidermis of theca of *P. commune.*

I. Transpiration as a Function of Living Protoplasm; II. Transpiration, and III. Evaporation, in a Saturated Atmosphere.

By the Rev. G. HENSLOW, F.L.S.

[Read 2nd June, 1887.]

I. TRANSPIRATION AS A FUNCTION OF LIVING PROTOPLASM.

Introductory.—That green leaves and other parts of plants transpire vapour of water from their surfaces has long been known; that this transpiration is greater by day than at night, and that it is augmented by heat, has been equally well ascertained; that it is chiefly induced by the absorption of the red and violet, and to a less extent by some other of the rays of the solar spectrum, when white light impinges upon organs containing chlorophyll, has been satisfactorily demonstrated. That it is *not*, however, strictly speaking a function of chlorophyll, *per se*, but rather one of living protoplasm generally, whether green or colourless, seemed to require confirmation, and is one of the results of the experiments herein to be described.

My object has been to find out, if possible, how far transpiration is effected by light, both white as well as coloured, and by temperature without the aid of chlorophyll; and if under this condition it could be compared with the purely physical property of evaporation which takes place from all moist substances.

MM. Bonnier and Mangin, in their experiments upon the respiration and transpiration of Fungi, arrived at the following conclusions [*]:—

"1. La transpiration est augmentée par l'élévation de la température.

"2. La transpiration diminue quand l'état hygrométrique de l'air augmente.

"3. La lumière diffuse augmente la transpiration des Champignons."

With reference to the differences between Transpiration and Evaporation, M. Leclerc has arrived at the following results [†]:—

"1°. La transpiration est indépendante de la lumière.

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[*] Ann. des Sci. Nat. 6 sér. tome xvii. p. 302.

[†] Ibid. 6 sér. tome xvi. p. 274.

"2°. Elle est nulle dans une atmosphère saturée.

"3°. Elle est fonction de l'état hygrométrique de l'air.

"Cette fonction est répresentée assez exactement par l'équation $E=a(F-f)+c$, dans laquelle a est un coefficient variable avec chaque plante et chaque expérience; F, la tension de la vapeur d'eau correspondant à la température de l'atmosphère dans chaque expérience; f, la tension de la vapeur d'eau contenue dans l'atmosphère au même moment; c, une constante, positive ou négative.

"Dalton a trouvé que la quantité d'eau qu'évapore une surface d'eau située dans une atmosphère partiellement saturée, peut s'exprimer par une équation identique.

"4°. Si la transpiration est plus active dans la plante exposée au soliel que dans la plante à l'ombre, cela tient:—(*a*) Aux rayons calorifiques qui, accompagnent toujours les rayons lumineux, échauffent les tissues; (*b*) aux fonctions d'assimilation des feuilles."

M. Leclerc gives a short notice of the investigators of Transpiration, from Woodward in the 17th century to Wiesner in 1876. The paper of the last-mentioned writer appeared subsequently to M. Leclerc's experiments, and he only briefly notices it to observe that Wiesner reduces the function to a form of evaporation; so that:—"Le phénomène de la transpiration devient un phénomène entièrement physique et une fonction de la température de la plante; mais il ne semble pas avoir cherché s'il n'y aurait pas une relation entre la transpiration et l'état hygrométrique de l'air."

M. Masure, however, arrives at a different conclusion*, viz., that transpiration is not at all a phenomenon of simple evaporation, since he found from his experiments that it is four times greater than the evaporation of pure water from the same amount of surface †. It is a function of vegetation, which continues at night, being then about one-tenth of that by day; and he attributes this relaxation to the absence of solar radiations; finally observing:—"La Transpiration des plantes est un phénomène complexe qui subit, d'une part les mêmes influences physiques que l'évaporation de l'eau pure et qui, d'autre part, s'effectuant sous l'empire des forces, physiologiques de la vie végétative, s'écarte nécessairement de ces lois suivant les besoins de la plante. Ce n'est que par des observations de toutes les heures et plus souvent répétées encore si c'était possible, qu'on peut espérer découvoir les raisons de ces écarts."

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* "Recherches sur l'Evaporation de l'eau libre, de l'eau contenue dans les terres avables, et sur la Transpiration des Plantes." Annales Agronomiques, 1880, tome vi. (*cf.* pp. 451 and 490).

† If this result be correct, it does not seem to agree with those obtained by comparing the transpiration of a living plant with the evaporation from the same plant when killed, as will be seen hereafter.

One great objection amongst others to the idea that transpiration is referable to evaporation, which in turn is regulated by temperature and the hygrometric state of the air, is that a living leaf loses water more slowly than when it is dead*. I have proved this repeatedly in the following manner. Taking a variety of leaves and dividing them longitudinally, I suddenly killed one half by scalding. I then weighed them, and again at short intervals till the two halves of each leaf had dried up and lost no more weight. The killed half dried up faster, the loss per hour being greater than from the living half.

As another remarkable difference, it will be seen from the tables given below that while living parts of plants can *absorb vapour at night* in a saturated atmosphere, wet cotton-wool never does so.

For further details upon the effects of temperature, and of different hours of the day and of month of the year, upon Transpiration as compared with Evaporation, the reader is referred to M. Masure's interesting paper.

EXPERIMENTS WITH MUSHROOMS.

The first series of experiments were made with Mushrooms transplanted separately from a bed into small pots about two inches deep. The latter were entirely enveloped in guttapercha sheeting, cotton-wool being wrapped round the stipes to protect it from injury, where the sheeting was carefully and somewhat tightly fastened, so that no moisture could escape otherwise than by transpiration from the plant itself.

The following table gives the results of observations upon three examples, from December the 28th, 1885, and of a fourth from Jan. 23rd, 1886.

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* Dr. Vines also mentions this fact, 'Phys. of Plants,' p. 105.

Results of Experiments.

	No. of hours.	Loss per hour, No. I.	Loss per hour, No. II.	Loss per hour, No. III.		Min.	Max.
1885. Dec. 28	6	R. ·030	Y. ·021	V. ·043	Dull.	42°	45°
	18	D. ·026	D. ·020	D. ·037		39	41
„ 29	6	Y. ·016	R. ·020	G. ·040	Fine, bright.	39	44
	18	D. ·024	D. ·020	D. ·035		35	42
„ 30	6	G. ·013	V. ·015	R. ·035	Fine.	40	42
	16·5	D. ·018	D. ·015	D. ·020		42	42
„ 31	8	V. ·022	G. ·022	Y. ·030	Very dull.	40	47
	18	D. ·011	D. ·011	D. ·032		40	48
1886. Jan. 1	6	Cl. ·043	Cl. ·035	Cl. ·045	Very dull.	51	53
	16	D. ·022	D. ?	D. ·031		51	53
„ 2	6·5	R. ·021	Y. ·018	V. ·042	Fine.	50	52
	16	D. ·020	D. ·022	D. ·034		51	56
„ 3	7·5	Y. ·030	R. ·022	G. ·034	Fine.	49	56
	17·5	D. ·019	D. ·013	D. ·031		49	52
„ 4	6·5	G. ·027	V. ·024	R. ·035	Dull, rain.	51	52
	17	D. ·024	D. ·025	D. ·034		42	51
„ 5	8	V. ·032	*G. ·031	Y. ·032	Very fine.	44	47
	15·75	D. ·026	D. ·027	D. ·042		38	46
„ 6	7	Cl. ·030	*Cl. ·031	Cl. ·063	Heavy snow.	38	40
	17·5	D. ·028	D. ·023	D. ·036		36	42
„ 7	7	R. ·010	*Y. ·034	V. ·046	Fine.	36	40
	17	D. ·020	D. ·020	D. ·030		35	41
„ 8	7	Y. ·029	[decayed]	G. ·036	Fine.	36	40
	14	D. ·019	......	D. ·028		35	42
„ 9	7	G. ·020	......	R. ·033	Dull.	36	39
	18·75	D. ·016	......	D. ·024		36	40
„ 10	5	V. ·016	......	Y. ·023	Foggy.	38	41
	17·75	D. ·017	......	D. ·023		38	43
„ 11	7	Cl. ·037	......	Cl. ·033	Very fine.	39	41
	17	D. ·015	......	D. ·023		38	43
„ 12	7·25	R. ·022	......	V. ·027	Overcast.	39	42
	18·25	D. ·015	......	D. ·019		39	44
„ 13	5·75	Y. ·031	......	G. ·043	Fine.	40	44
	17·25	D. ·015	......	D. ·020		40	43
„ 14	24	G. ·015	......	R. ·030	Dull.	39	45
„ 15	6·25	V. ·010	......	Y. ·020	Fine.	42	44
	16·25	D. ·014	......	D. ·024		39	45
„ 16	7·25	Cl. ·022	......	Cl. ·023	Fine.	42	43
	16.25	D. ·016	......	D. ·018		40	44

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* See below, p. 295.

	No. of hours.	Loss per hour, No. IV.		Min.	Max.
1886. Jan. 23	5·5	R. ·049	Snow, dull.	40°	40°
	14·5	D. ·042		39·5	44
„ 24	8	Y. ·036	Snow, sunshine.	40	42
	15·5	D. ·034		40	42
„ 25	10·5	G. ·024	Very dull.	42	46
	13·5	D. ·032		44	48
„ 26	10·5	V. ·036	Very fine.	42	46
	13·5	D. ·038		42	48
„ 27	10	R. ·047	Very fine.	42	45
	14	D. ·038		42	48
„ 28	9·5	Y. ·035	Foggy, then fine.	42	44
	14·5	D. ·039		42	48
„ 29	9	G. ·039	Dull.	42	44
	15	D. ·036		42	47
„ 31	9	V. ·046*	Very fine.	42	45
	15	D. ·049		42	46
Feb. 1	10	Cl. ·041	A.M. dull, P.M. fine.	42	46
	14	D. ·045		44	50
„ 2	8·5	R. ·044	Fine.	44	46
	15·5	D. ·040		44	48
„ 3	9·5	Y. ·042 [dying]	Dull.	42	46

Effects of Light.

Arranging the preceding results under the different colours†, they give the following mean losses per hour :—

No. I.

(Dec. 28, 1885, to Jan. 16, 1886.)

Range of mean Min. and Max. Temps.	R. 41°·7–44°·7	Y. 44°–46°.	G. 41°·5–44°·5	V. 41°–44°·7.	Cl. 42°·5–44°·2	D. 40°–43°.
	·030	·016	·013	·022	·043	Mean of nineteen observations:
	·021	·030	·027	·032	·030	
	·010	·029	·020	·016	·037	
	·022	·031	·015	·010	·022	
Means	·021	·026	·019	·020	·033	·020

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† The glasses used were the same as described in my former paper :—"A Contribution to the Study of the Relative Effects of Different Parts of the Solar Spectrum on the Transpiration of Plants," Journ. Linn. Soc. Bot. vol. xxii. p. 81.

No. II.

(Same period.)

Range of mean Min. and Max. Temps.	R. 44°–50°.	Y. 46°–48°·5.	G. 42°–47°.	V. 45°·5–47°.	Cl. 44°·5–46°·5	D. 40°·7–46°.
	·020	·021	·022	·015	·035	Mean of ten observations:
	·022	·018	·031	·024	·031	
Means	·021	·019	·026	·019	·033	·020

No. III.

(Same period.)

Range of mean Min. and Max. Temps.	R. 41°·5–44°.	Y. 41°–44°·5.	G. 41°–46°.	V. 41°·7–45°.	Cl. 42°·5–44°·5	D. 40°·5–45°·1.
	·035	·030	·040	·043	·045	Mean of nineteen observations:
	·035	·032	·034	·042	·063	
	·033	·023	·036	·046	·033	
	·030	·020	·043	·027	·023	
Means	·033	·026	·038	·040	·041	·028

No. IV.

(Jan. 23 to Feb. 3, 1885.)

Range of mean Min. and Max. Temps.	R. 41°·8–45°.	Y. 41°·3–44°.	G. 42°–45°.	V. 42°–45°·5.	Cl. 42°–46°.	D. 42°·1–47°.
	·049	·036	·024	·036	·041	Mean of ten observations:
	·047	·035	·039	·046	......	
	·044	·042	......	......	......	
Means	·047	·038	·031	·041	·041	·039

The means of all four specimens will therefore be as follows:—

R.	Y.	G.	V.	Cl.	Dk.
·0305	·0267	·0285	·0300	·0370	·0267.

These may be practically represented:—

·030	·027	·028	·030	·037	·027.

These results agree with those obtained from plants possessing chlorophyll, so far as the maxima occur under red, violet, and clear glasses, while yellow, green, and total darkness give minima. This result is almost as obvious in the means for each specimen respectively.

If, however, we neglect third places of decimals, we may write the above thus:—

·03	·03	·03	·03	·04	·03.

This result shows that the differences between the effects of any particular colour is really almost inappreciable; whereas the augmentation under clear light is more pronounced. This last result, as mentioned above, was obtained by MM. Bonnier and Mangin. It should be observed that, taking high places of decimals (as the third or fourth), one runs the risk of appearing to emphasize what may be fictitious results. So far as they go, however, it is at least somewhat remarkable that they should so completely tally with the results obtained from green plants, where the differences are more manifest.

Effects of Temperature.

The mean temperatures from December 28, 1885, to January 15, 1886, during which period the observations were made upon the specimens Nos. I., II., and III., rose during the first four days, fluctuated from Jan. 1st to the 4th, and then fell again. Grouping the total amount of losses per hour during these three successive periods, the results are as follows:—

	Mean Max.	No. I.	No. II.	No. III.
Dec. 28 to 31	43°·5	·018	·020	·034
Jan. 1 to 4	53°·5	·026	·023	·036
Jan. 5 to Feb. 15 ...	43°·0	·020	[decayed]	·031

Comparing the losses per hour under the lowest minimum temperature with those under the highest maximum, the effect under each glass is shown as follows:—

	Lowest Min. No. I.	Highest Max. No. I.	Lowest Min. No. II.	Highest Max. No. II.	Lowest Min. No. III.	Highest Max. No. III.
R...	36° ... ·010	52° ... ·021	39° ... ·020	52° ... ·021	36° ... ·033	52° ... ·035
Y...	36 ... ·029	56 ... ·030	36 .. ·034*	56 ... ·030	38 ... ·023	47 ... ·041†
G...	36 ... ·020	52 ... ·027	40 ... ·022	52 ... ·027	36 ... ·036	56 ... ·036
V...	38 ... ·016	47 ... ·027†	40 ... ·015	47 ... ·027	36 ... ·046	52 ... ·042
Cl...	38 ... ·030	53 ... ·043	38 ... ·031	53 ... ·043	38 ... ·063	53 ... ·045

These results are sufficient to show that temperature has a marked effect upon the transpiration, when no account is taken of any difference between light and darkness. The effect, however, becomes much more pronounced when Mushrooms are transferred from a warm room to a cool one, and allowed to remain in each for definite periods and of the same duration.

Three Mushrooms were grown in separate pots and protected as before. They were placed for twenty-four hours alternately in a cool room with no fire in it, and in a warm one where a fire burned every day. They were always in total darkness, being enclosed in a cardboard box. The following are the total losses in twenty-four hours :—

		I.	II.	III.	Min.	Max.
1886.		grms.	grms.	grms.		
Dec. 6– 7...	Cool room	1·50	·82	1·16	50°	56°
„ 7– 8...	Warm „	3·38	1·68	2·73	52	68
„ 8– 9...	Cool „	2·18	1·19	1·81	44	59
„ 9–10...	Warm „	3·57	2·61	2·90	48	76
„ 10–11...	Cool „	2·67	·85	1·15	44	56
„ 11–12...	Warm „	3·15	1·45	1·93	50	62
„ 12–13...	Cool „	·99	·92	1·02	47	56
„ 13–14...	Warm „	2·27	1·37	1·71	48	61

Transpiration from Living Mushrooms compared with Evaporation from Saturated Dead Specimens.

Two of the three specimens, viz. Nos. I. and III., together with No. IV., were scalded after the above experiments were completed. All superficial moisture being carefully removed by slight pressure between sheets of blotting-paper, they were submitted for four and three days and nights respectively to diffused sunlight and total darkness respectively, with the following results:—

---

* Exceptionally increased loss by dying and drying up rapidly.

† Means of two observations.

Loss per hour by Day, No. I.	No. III.	Min.	Max.	Loss per hour by Night, No. I.	No. III.	Min.	Max.
·023	·044	39°·5	41°	·017	·023	39°·5	41°
·028	·041	38	40	·014	·012	38	42
·017	·020	40	40	·013	·017	39·5	44
·016	·022	40	42	·014	·022	40	42
Means ·021	·032	39·4	40·7	·014	·018	39·2	42·2

Loss per hour by Day, No. IV.	Min.	Max.	Loss per hour by Night, No. IV.	Min.	Max.
·043	42°	42°·5	·035	41°	44°
·025	38	42	·020	40	44
·017	41	45	·014	46	50
Means...... ·028	40	43	·023	42	44

Total mean loss by Day.	Min.	Max.	Total mean loss by Night.	Min.	Max.
·027	40°	42°	·018	40°	43°

Comparing these results with the mean losses by transpiration under clear diffused light and total darkness, the latter were as follows:—

Total mean loss by Day.	Min.	Max.	Total mean loss by Night.	Min.	Max.
·036	42°·3	45°	·029	41°	45°

In both cases the loss is greater by transpiration than from an artificially saturated condition, and whether the loss be by transpiration or evaporation, it is greater by day than by night.

This may appear strange with regard to evaporation, but it is a well-known fact that dark bodies especially, such as a dead mushroom, can absorb radiant energy and convert it into heat. This is well illustrated by small objects, such as dead leaves, pieces of bark, small stones, dead insects, &c., which when lying on ice gradually sink into it, sometimes to a depth of several inches. This is frequently observable on the glaciers of Switzerland, and that, too, when the temperature of the air in contact with the ice must be close upon the freezing-point of water.

That a mushroom with blackened gills absorbs much light is further proved by making an alcoholic solution. If this be examined with a spectroscope, it will be found that the only light which is transmitted is a very dull red and green, showing how much of the spectrum is arrested.

There is another point illustrated in the above experiments, namely, that a living organism transpires *cæteris paribus* less than when dying or dead, *i. e.* when it is replaced by evaporation. Thus specimen No. II. will be seen to have transpired more largely from Jan. 5 to 7 (indicated by * p. 289), when decay had set in, though there was no special rise of temperature to account for it. It was also more pronounced by day than at night.

Similarly, specimen No. IV. was beginning to dry up about Jan. 31 (* p. 290). From that date to the 3rd, the loss per hour was markedly greater than it had been previously.

Experiments with Etiolated Seakale.

The following experiments were made with plants of Seakale which had at first been grown in a dark cellar. One had a rhizome 3 inches in length, and foliage consisting of white petioles with purplish arrested blades. The other had a rhizome about 5 inches in length, with long petioles varying from 6 to 12 inches in length. The rhizomes, with a few rootlets attached, were wrapped up in saturated cotton-wool, and the whole enveloped in guttapercha sheeting, so that no moisture could possibly escape except from the exposed petioles. The plants were subjected to light transmitted through coloured glasses successively by day, and placed in total darkness at night. They were carefully weighed every morning and evening, and the losses by day and by night reduced to losses per hour for each period respectively, as in the case of the Mushrooms described above.

The following are the results obtained :—

	No. of hours.		Loss per hour, No. I.	Loss per hour, No. II.		Min.	Max.
1886.							
March 15	13·5	Dark.	·036	·067		41°	46°
„ 16	10	R.	·041	·070	Dull.	39	42
	14	D.	·032	·062		38	43
„ 17	10	Y.	·034	·065	Fine.	40	40
	14	D.	·032	·063		41	44
„ 18	10	V.	·034	·070	Dull.	40	44
	9·5	D.	·031	·073		42	46
„ 19	10	G.	·030	·083	A.M. dull;	44	52
	14·5	D.	·029	·080	[P.M. fine.	49	52
„ 20	10	Cl.	·031	·079	Fine.	50	54
	14	D.	·032	·070		53	56
„ 21	9·5	R.	·026	·076	Dull.	53	56
	15	D.	·030	·111		53	57
„ 22	9·5	Y.	·028	·026	Dull.	52	58
	14·5	D.	·028	·070		54	57
„ 23	10	G.	·031	·089	A.M. dull;	54	56
	14	D.	·043	·085	[P.M. fine.	55	60
„ 24	9·5	V.	·053	·087	Fine.	55	59
	15	D.	·044	·088		56	57
„ 25	9·5	Cl.	·051	·090	Dull.	56	59
	14	D.	·039	·073		56	59
„ 26	10	R.	·051	·084	Dull.	55	59
	14	D.	·044	·077		56	58
„ 27	10	Y.	·043	·066	Dull.	56	56
	14·5	D.	·035	·065		56	58
„ 29*	9·5	G.	·042	·072	Dull, rain.	54	56
	14	D.	·037	·069		50	55
„ 30	9·5	V.	·040	·070	Fine.	52	54
	14·5	D.	·037	·072		51	54
„ 31	10·5	Cl.	·044	·067	Fine.	50	54
	13·5	D.	·037	·054		49	52

Effects of Light.

Arranging the preceding results under the different colours, they give the following mean results of the losses per hour :—

No. I. (March 16–32, 1886.)

	R.	Y.	G.	V.	Cl.	D.
	·041 ·026 ·051	·034 ·028 ·043	·030 ·031 ·042	·034 ·053 ·040	·031 ·051 ·044	Mean of fourteen observations :
Means	·039	·035	·034	·042	·042	·034

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* Observations not taken on March 28.

No. II.

	R.	Y.	G.	V.	Cl.	D.
	·070	·065	·083	·070	·079	Mean of fourteen observations:
	·076	·026	·089	·087	·090	
	·084	·066	·072	·070	·067	
Means ...	·077	·052	·081	·076	·079	·073

Taking the means again of the above, the results are as follows:—

R.	Y.	G.	V.	Cl.	D.
·058	·043	·058	·059	·060	·053 ;

or, practically,

·06	·04	·06	·06	·06	·05.

It will be seen that these means agree very closely with what is experienced with green plants; in so far as red, violet, and clear light furnish maxima, yellow, and generally green as well as total darkness, minima. These results, moreover, agree with those obtained by Wiesner, who found that etiolated plants absorbed the same rays, but in a lessened degree. Temperature, however, bears so important a part that apparently exceptional results may easily mark the general law.

A somewhat conspicuous difference will be observed between the effects of green light on the two specimens: thus, while No. I. has the most decided minimum, No. II. has the most decided maximum. I met with a similar experience when experimenting with green plants; thus, while one batch of Lettuces gave a mean under green the next lowest to that under yellow light, both a second and a third batch gave the mean under green next highest after red, violet, and clear glass. On the other hand, Palms gave the mean under green as the lowest minimum.

The green glass used transmitted the absorption-bands III. to VI. Hence there seems to be some peculiarity about the effect of green glass which requires further investigation.

The lowest minimum is most constantly under yellow glass; and the results with colourless glass agree therefore with those obtained with green plants, in which I have pointed out that yellow light must have a *retarding* effect on transpiration, since the glass used transmits all the red as well, whereas the red glass is absolutely pure without a trace of any other colour. It is a remarkable coincidence that MM. Bonnier and Mangin found that the luminous rays, especially red and yellow, retarded respiration, other conditions being equal*.

Effects of Temperature.

Comparing the losses per hour under the lowest minimum temperature with those under the highest maximum, the effect under each glass is shown as follows :—

	Lowest min.	No. I.	No. II.	Highest max.	No. I.	No. II.
R.	39°	·041	·070	59°	·051	·084
Y.	40	·034	·065	58	·028	·026
G.	44	·030	·083	56	·036†	·080†
V.	40	·034	·070	59	·053	·087
Cl.	50	·031	·079	59	·051	·090

By comparing these results, it will be seen that increments of temperature *generally* increase markedly the transpiration. A curious exception is noticeable with yellow light, in which an increase of 18° is accompanied by a decreased power of transpiring. Somewhat similar results seem noticeable with Mushrooms ‡.

With regard to the effects of temperature apart from light, if we group the means in successive increments as follows, the effect is clearly seen.

The following figures represent the loss per hour at night in total darkness :—

	°	I.	II.
March 16	40·5	·03	·06
„ 17	42·5		
„ 15	43·5	·03	·07
„ 18	44·0		
„ 19	50·5	·03	·07
„ 31	50·5		
„ 29	52·5	·04	·07
„ 30	52·5		
„ 20	54·5	·03	·08
„ 21	55·0		
„ 22	55·5		
„ 24	56·5	·04	·09
„ 26	57·0	·04	·08
„ 27	57·0		
„ 23	57·5		
„ 25	57·5		

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* "La Fonction Respiratoire chez les Végétaux." Ann. des Sci. Nat. tome ii. p. 377.

† Means of two observations.

‡ See the corresponding table p. 293, especially Nos. I. and II.

This indicates a gradual increase of transpiration in accordance with slight increments of temperature.

As with Mushrooms so with etiolated Seakale, the effect of temperature becomes more marked when the specimens are transferred from a cool room to a warm one, and *vice versâ*, as the following experiment shows:—Two specimens of Seakale of about the same size as the preceding, and carefully protected as described, were placed for twenty-four hours alternately in a cool room without a fire and in a warm one. They were not enclosed, but exposed to diffused daylight.

	No. I.	Loss in 24 hours. No. I.	Loss in 24 hours. No. II.	Min. temp.	Max. temp.
1887.		grammes.	grammes.		
April 7–8	Cool room.	2·80	1·83	44°	51°
„ 8–9	Warm „	2·24	2·34	49	61
„ 9–10	Cool „	·89	·86	46	56
„ 10–11	Warm „	1·46	1·55	48	69
„ 11–12	Cool „	·71	·76	45	58
„ 12–13	Dark „	1·20	1·13	54	64

Transpiration compared with Evaporation.

The two specimens of Seakale were scalded after the termination of the experiments on transpiration. All superficial moisture being carefully removed, they were subjected for a week to successive coloured glasses by day and to total darkness at night, with the following results:—

Colour of glass.	No. I.	No. II.	Min.	Max.
Dark	·115	·162	52°	54°
R.	·121	·201	52	56
D.	·075	·112	55	58
Y.	·117	·210	51	58
D.	·074*	·133*	50	56
G.	·060	·110	52	54
D.	·048	·070	51	56
V.	·050	·050	52	54
D.	·033	·047	54	56
Cl.	·043	·048	50	58

The first observation to be made on these results is that up to (*) the losses were greater by day than by night; subsequently the evaporation steadily declined, apparently irrespective of light. Taking the means of the above, we have as results, irrespective of colour :—

Mean loss by day.	Min.	Max.	Mean loss in darkness.	Min.	Max.
·106	51	56	·087	52	56

Comparing these results with the mean losses by transpiration irrespective of colours :—

Mean loss by day.	Min.	Max.	Mean loss in darkness.	Min.	Max.
·056	50	53·3	·049	53·3	57

In both cases, as with Mushrooms, the loss is greater under light than in darkness ; and probably the same interpretation may be given here as with the former experiments.

Again, as it was observed (on p. 294) that the transpiration of Mushrooms was greater than their evaporation, similarly is it with Seakale. In the latter case the evaporation is nearly double that of transpiration. So great a difference possibly depends upon the different natures of the cellular tissues of these two plants, though I confess at present to be quite unable to explain it. That there is some similarity, if not identity in part, between the two processes of transpiration and evaporation seems obvious, yet that the *vitality* of a living plant has an important modifying influence is equally apparent. Leclerc considers transpiration as not being due to light *per se*, but to the calorific rays which accompany it. But though the chlorophyll absorption-band No. I. coincides pretty nearly with the maximum of the calorific rays (as Langley and Abney have shown *), it is difficult to see in what way Leclerc would explain how a maximum of transpiration is obtained with violet light, as both Wiesner and myself have proved, and which we believe to be converted into heat, and thus do work.

One great point of difference between transpiration and evaporation in their final results consists in the relatively greater quantity of water lost, and that with a greater rapidity, by evaporation as compared with transpiration. Thus, for example, the mean loss by transpiration under all lights of a plant of *Echeveria* was ·033 gramme per hour ; while the same plant scalded to death evaporated ·068 gr. per hour under a very similar range of temperatures. The inference is, that living protoplasm has a power of controlling and regulating the loss of water which a dead organic structure does not possess.

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* "The Influence of Water in the Atmosphere on the Solar Spectrum and Solar Temperature," by Capt. Abney, R.E., F.R.S., and Col. Festing. Proc. Royal Soc. xxxv. p. 328 (1883).

CONCLUSIONS.

The general conclusions which the above-described experiments seem to warrant are, that plants, such as Mushrooms, which do not possess chlorophyll at all, transpire more under light than in darkness, but exhibit slight, but not very appreciable, differences under light of various colours. Transpiration, however, appears to be more sensitive to increments of temperature than to colours, and perhaps than to pure white light itself.

Etiolated plants, as Seakale, which under normal conditions would be green, still show some slight difference, due to coloured rays, such as are, however, much more pronounced with plants possessing chlorophyll.

In both cases transpiration is a function of living colourless protoplasm ; this function, however, being greatly enhanced by the presence of chlorophyll, in consequence of the power possessed by the latter substance of absorbing certain rays, which then, by their conversion into heat, raise the temperature within the leaf and thereby increase the loss of the vapour of water.

Lastly, the difference in the effects of transpiration from a living organism and evaporation from a dead one can easily be seen in the usually relatively greater amount of water lost under the latter process under similar conditions and in the same space of time. A further difference will be noted hereafter; and the reader may be referred to M. Masure's paper, mentioned above, for other differences.

Since this paper was written a short communication from M. Ph. van Tieghem * has appeared, in which he also suggests that the term *transpiration* should be given to the vaporization of water from protoplasm, and which occurs independently of chlorophyll. This, he remarks, is a process common to animals as well as vegetables, or to all living beings :—"Elle croît, comme on sait, avec la température, avec la sécheresse et l'agitation de l'air. La lumière aussi s'accélère ; au soleil, un organe sans chlorophylle, un pétale de Mauve ou de Lis, par example, transpire jusqu'à deux et trois fois plus fortement qu'à l'obscurité."

* Bull. de la Soc. Bot. de France, 1886, p. 152.

To this general property of transpiration the "chloroleucites," or chlorophyll-grains, add their quota by means of the particular rays absorbed by them in sunlight. This second phenomenon, be it observed, is much more intense than the former, and Tieghem proposes the term "chlorovaporisation" to represent the "transpiration chlorophyllien."

II. TRANSPIRATION IN A SATURATED ATMOSPHERE.

M. Dehérain states * that transpiration continues indefinitely in a saturated atmosphere from living leaves undetached from the plant; whereas (he says) a cotton wick dipped in water after two hours lost ·076 gramme, after three hours' exposure to sunlight ·086 gr., but after four hours there was no further loss. Wiesner also remarks that plants can transpire in a saturated atmosphere, but only under the influence of light, inasmuch as the temperature within the leaf must be warmer than without, and this increase is produced by the conversion into heat of the rays which are absorbed.

On the other hand, M. Leclerc, in his paper alluded to above, states that transpiration does *not* take place in a saturated atmosphere.

Lastly Knop (Veg. Stat. vi. 255) found that a moist piece of paper or wood lost weight when kept for some time in a confined space over water.

The following experiments were made for the purpose of testing these results, and, as far as they go, they certainly seem to corroborate Dehérain and Wiesner with regard to transpiration, and Knop in that a dead substance will continue to evaporate for many days in an apparently saturated atmosphere.

The experiments were conducted in a large glass jar constructed like a hat with a broad rim. A thick piece of plate glass was well luted to the rim by a band of putty about two inches broad and a quarter of an inch thick. A small hole, about half a line in diameter, was bored in the centre of the plate, through which a fine platinum wire was passed, and upon which was suspended the leaf or cotton-wool &c. The wire was attached to one of the pans of a delicate balance, and, except when the specimen was required to be weighed, the hole was plugged with putty. The latter was removed at intervals, so that the leaf &c. could be weighed while still remaining within the glass jar. A layer of water covered the bottom of the jar; and a wet- and a dry-bulb thermometer were suspended within it; the mercury was always exactly at the same height in both of them.

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* Ann. des Sci. Nat. 5 sér. tome xii. 1869, p. 5.

The jar was either exposed to diffused light, or else entirely excluded from light by means of oiled cloth.

The following is a selection of experiments to represent three types of foliage.

In the following cases, selected out of several, it will be observed that as long as the plants were exposed to diffused daylight, they continued to lose weight, although the atmosphere was apparently perfectly saturated all the time*.

Buxus sempervirens.

	Weight in grammes.*	Loss per cent.	Temp. (W. & D.).
July 9th.			
8 A.M.	3·240	……	67°
3 P.M.	3·155	·973	71
5 "	3·085	·221	73
10 "	3·035	1·626	69
July 10th.			
8 A.M.	3·045	† ·032	67·5
1 P.M.	3·035	·032	71
10 "	3·005	·098	71
July 11th.			
8 A.M.	3·115	† ·366	70
6 P.M.	2·950	5·296	75
July 12th.			
8 A.M.	2·965	† ·050	71
1 P.M.	2·965	·000	71
6 "	2·945	·067	72
10 "	2·955	† ·033	70
July 13th.			
8 A.M.	2·980	† ·084	69
2 P.M.	2·955	·083	71
5.30 P.M.	2·905	·016	76·5
10 P.M.	2·920	† ·051	67
July 14th.			
8 A.M.	2·940	†1·369	66
6 P.M.	2·925	5·102	69
July 15th.			
8 A.M.	2·960	†1·196	67
6 P.M.	2·950	·034	68
July 16th.			
8 A.M.	2·960	† ·036	67

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* The reader's attention is called to the instances of no loss by a * and a † represents a gain. In all other instances the numbers represent a loss per cent. of the entire weight of the leaves under examination.

Ligustrum vulgare.

	Weight in grammes.	Loss per cent.	Temp. (W. & D.).
August 4th.			
8 A.M.	2·965	......	71°
10 P.M.	2·795	·576	66
August 5th.			
8 A.M.	2·795	* ·000	66
1 P.M.	2·765	·106	68·5
6 „	2·760	·017	67
12 „	2·770	† ·036	64
August 6th.			
8 A.M.	2·770	* ·000	64
4.30 P.M.	2·615	5·595	68
12 P.M.	2·625	† ·015	63
August 7th.			
8 A.M.	2·630	† ·019	63
1 P.M.	2·610	·076	65·5
6 „	2·585	·095	64
12 „	2·600	† ·057	63
August 8th.			
8 A.M.	2·605	† ·019	64·6
6 P.M.	2·565	·153	65
11 „	2·675	† ·039	64
August 9th.			
8 A.M.	2·590	† ·059	62

Epilobium hirsutum.

	Weight in grammes.	Loss per cent.	Temp. (W. & D.).
July 17th.			°
9 A.M.	3·625		
11 „	3·585	1·1	65
1 P.M.	3·565	·55	64·5
5 „	3·510	1·51	64·5
10.30 P.M.	3·510	* 0·00	64
July 18th.			
8 A.M.	3·510	* 0·00	64
2 P.M.	2·860	18·51	67
10.30 P.M.	2·700	5·59	65
July 19th.			
8 A.M.	2·700	* 0·00	65
12 (noon)	2·660	1·44	67
6 P.M.	2·585	2·81	67
July 20th.			
8 A.M.	2·610	† ·09	64
4.30 P.M.	2·530	3·06	67
10 P.M.	2·530	* 0·00	67

Epilobium hirsutum (continued).

	Weight in grammes.	Loss per cent.	Temp. (W. & D.).
July 21st.			
8 A.M.	2·480	1·98	61°·5
3 P.M.	2·460	0·79	62
10.30 P.M.	2·460	* 0·00	62
July 22nd.			
5.30 P.M.	2·350	4·47	63
July 23rd.			
9 A.M.	2·350	* 0·00	62
2 P.M.	2·300	2·12	64

Between 6 P.M. one day and 8 A.M. on the following day, the plants very frequently either lost nothing (*), or else they gained weight (†).

The author of 'How Plants Feed' says:—"Knop found in one instance that a *Portulaca*, standing overnight in a bell-glass with moistened sides, did not lose, but gained weight, some dew having gathered on the foliage" (p. 37). That plants, especially when at all "wilted," to use the American term, can absorb dew and rain has been abundantly proved by Boucicault * and by myself †.

In carefully examining the specimens, of course through the glass jar, I could not detect that the gain was in consequence of any visible dew upon the surface. Indeed, the amount gained in each case is so minute, that it could only be detected by very careful weighing; but the fact that the gains all occurred during the evenings and nights, when the temperature fell, while the losses only occurred by day, are sufficient to indicate the occurrence as an undoubted fact; and while Knop only recorded it as an isolated instance, the above table establishes the property of gain as a law.

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* Annales de Chimie et de Physique, Mars 1878.

† Journ. Linn. Soc., Bot. vol. xvii. p. 313.

III. Evaporation in a Saturated Atmosphere.

Some cotton-wool, saturated with distilled water, and weighing 9·715 grammes, was suspended in the glass jar as described. The losses in weight were as follows :—

	Weight in grammes.	Loss per cent.	Temp. (W. & D.).
November 9th.			
8 A.M.	9·716	......	53°
6.30 P.M.	9·710	·005	53
November 10th.			
8 A.M.	9·700	·010	56
6 P.M.	9·695	·005	56·5
November 11th.			
8 A.M.	9·670	·025	52
6 P.M.	9·660	·010	52·5
November 12th.			
8 A.M.	9·645	·015	51
5.30 P.M.	9·630	·015	49
November 13th.			
9 A.M.	9·615	·015	49
7 P.M.	9·600	·015	47
November 14th.			
8 A.M.	9·585	·015	44
5 P.M.	9·580	·005	46
November 15th.			
8 A.M.	9·565	·015	43
November 16th.			
8 A.M.	9·540	·025	40
November 17th.			
9 A.M.	9·525	·015	45

The total loss was ·255 gramme, or on an average ·0232 gr. per day.

From Nov. 17th to Dec. 1st, or a fortnight, the cotton-wool was kept in the jar, which was completely closed during the whole time. On Dec. 1st it weighed 9·235 grammes, so that it had lost ·0217 gr. per day.

A piece of sponge weighing 18·005 grammes and saturated with distilled water was suspended in the same manner, and lost weight as follows :—

	Weight in grammes.	Loss per cent.	Temp. (W. & D.).
May 9th.	18·005		°
„ 10th.	17·980	·025	56
„ 11th.	17·940	·034	57·5
„ 12th.	17·930	·016	?
„ 13th.	17·890	·040	59
„ 14th.	17·855	·035	59
„ 15th.	17·840	·015	63
„ 16th.	17·785	·055	65
„ 17th.	17·713	·072	62
„ 18th.	17·705	·008	59

The total loss was therefore ·390 gramme, and the mean loss per day ·035 gramme.

These two cases, several times repeated and corroborated by others which I need not quote, fully prove that dead saturated substances continue to evaporate, notwithstanding that the atmosphere in which they are suspended is apparently saturated; we can only conclude with Knop that it is impossible to maintain the air saturated with vapour.

Since the temperatures within the jar are constantly changing, the capacity of absorption must vary accordingly, and when the temperature rises, one can understand that the air can absorb more vapour, and may extract it from the substance or leaf experimented with as well as from the water at the bottom of the jar. But when the temperature falls, it is not so easy to see why cotton-wool or a sponge should still lose moisture. Such, however, is evidently the case.

A point to notice in these experiments is that while living specimens *gained* weight at night, dead substances never did so, but *lost* weight under all circumstances. Thus, when the glass jar was entirely excluded from light, and a piece of cotton-wool saturated with distilled water, weighing 8·670 grammes, was suspended within it for seven days, it lost ·165 gramme, or ·022 gr. per day. It would seem, therefore, that the power to absorb the vapour of water must be regarded as a property of living protoplasm, since dead cellular tissue (as cotton-wool) entirely failed to do so; and this furnishes an additional difference between living and dead organic structures.

A Revision of the Genera *Microstylis* and *Malaxis*.

By H. N. Ridley, M.A., F.L.S.

[Read 16th June, 1887.]

The genera treated of in this paper, together with *Oberonia* and *Liparis*, constitute a fairly natural group of Orchids, the *Malaxideæ*. Mr. Bentham, in 'Genera Plantarum,' iii. p. 465, separates the group into *Malaxeæ*, comprising *Malaxis* and *Microstylis*, and *Liparieæ*, including *Oberonia*, *Liparis*, *Platyclinis*, *Calypso*, *Oreorchis*, *Corallorhiza*, *Tipularia*, *Aplectrum*, and *Hexalectris*. Dr. Pfitzer, in his recently published 'Entwurf einer naturlichen Anordnung der Orchideen,' expels from the section the last three genera and *Platyclinis*, referring the latter to the neighbourhood of *Cœlogyne* and *Pholidota*, *Hexalectris* to that of *Bletia*, *Tipularia* and *Oreorchis* to *Phajineæ*. *Ephippianthus*, which Mr. Bentham refers to *Liparis*, seems to me quite distinct generically, and more nearly allied to *Calypso*. *Oberonia* has been added by Professor Reichenbach to the genus *Malaxis*; and in this he has been followed by a few botanists. To me, however, it seems quite distinct in its habit, distichous leaves, and cylindrical spikes of flowers, which more resemble those of some Asiatic *Microstyles* than those of *Malaxis*. I should class it, therefore, close to *Microstylis*.

I believe the best and most natural way of classifying the *Malaxideæ* is by the column. *Malaxis*, *Microstylis*, and *Oberonia* possess a short thick column and flowers with the lip uppermost; while in *Liparis*, *Calypso*, *Ephippianthus*, *Corallorhiza*, and *Oreorchis* the column is long and slender, and the flowers erect.

The relations of the two genera *Microstylis* and *Liparis* are very interesting. Both occupy nearly the same area, occurring in almost all the regions of the world, temperate and tropical, though the latter genus is far more abundant, and consequently somewhat more widely spread than the former. In all the species of each genus the characteristic form of the flower keeps true; so that there is never any doubt as to which genus any of the plants may be referred; but the vegetative organs show very distinct adaptive modifications in different climates and localities. What is very remarkable is that the same modifications in both genera seem to be characteristic of a region; so that we find in the same region species of both *Microstylis* and

Liparis resembling each other in vegetative organs. Thus, in the Himalayan Mountains we have *Liparis atropurpurea*, with a swollen stem covered with pale sheaths, and terminated by a tuft of thin membranous leaves, as in *Microstylis Wallichii* from the same region. *Liparis elliptica* has a solitary, erect, oblong leaf, and a short stem with an abruptly swollen pseudobulb, very similar to that of *Microstylis calycina*. Still more striking are the resemblances between *Liparis acutissima* and *Microstylis Godefroyæ*, both from Siam; *Liparis purpurascens* from Madagascar and *Microstylis stelidostachya* from the Comoro Islands; *Liparis brachystalix* and *Microstylis caulescens* from the Andes of Ecuador. So peculiar are some of the modifications, that it is often possible to guess from vegetative characters alone from which region a plant has come. The section *Coriifoliæ* of *Liparis* is, however, not at all represented in *Microstylis*. I am inclined to think that *Oberonia*, which occurs over the same region as the thick-leaved Liparids, takes its place.

Androchilus, a monotypic genus from Mexico, described by Liebmann in 'Forh. Skand. Naturf. Möde,' iv. p. 197, is referred by Mr. Bentham (Gen. Plant., Addenda, p. 1225) to the genus *Liparis* without his having seen a type-specimen; but on reading carefully the author's long description, it seems to me that the plant intended was one of the *Neottieæ*. For I do not know any Malaxideous plant that has a pubescent scape, ovary, and bracts or linear clavate pollinia, or a fasciculated root, while adnation or connivence of the posticous sepal with the petals is at least extremely rare, and possibly only accidental in this group. All these characters, however, are common in the *Neottieæ*; while the peculiar structure of the stamens as described by Liebmann may be due to a misinterpretation of the anther of such a plant as *Spiranthes*. *Gastroglottis*, Blume (Bijdr. p. 397), may possibly belong to this section of plants; but his description is quite insufficient to determine what was intended, and I have seen no type. *G. montana*, Kuhl and Hasselt, in Reichb. f. Xenia Orch. ii. p. 96, t. 129, seems certainly no Malaxid, but more resembles *Pholidota*.

MICROSTYLIS.

The habit of a typical *Microstylis* is, as has been said, very much that of a typical *Liparis*. There is a shorter or longer stem, swollen after flowering into a pseudobulb and covered with one or more loose white membranous sheaths. The rhizome from which these pseudobulbs rise is usually very short, and emits but few roots. It is never so long as it is in several Liparids, such as *L. nepalensis*. *Microstylis commelinifolia* has creeping stems entirely covered with alternate leaves, from the axils of which the scapes arise. It grows in thick masses, and, as its name denotes, resembles much a Commelinaceous plant. *M. caulescens* has also a creeping or prostrate stem covered with narrow suberect leaves, quite unlike anything else in the genus.

Leaves.—The number of leaves on a plant varies from one to ten. The small green-flowered Dienias of South America possess no more than a single leaf, though the sheaths of the stem are frequently green and foliaceous. Many species have two leaves, which are often a little distant apart. In *M. Rheedii* and some others the more numerous leaves are scattered along the whole length of the erect stem; but usually in the *Crepidium* section the leaves are clustered in a whorl at the top of the stem, which is covered below by mere sheaths. In *M. commelinifolia* and *M. caulescens*, as has been said above, the long stems are entirely covered with numerous small leaves. The form of the leaves is elliptic, ovate, cordate, or lanceolate, with a sheath at the base, between which and the lamina there is often a short petiole. The texture is thin and membranous, the edges often crisped, especially in the section *Crepidium*, in which also they are commonly very oblique. When there are several leaves, they are usually very unequal in size and often dissimilar in shape, the lower ones being much smaller, and often rounder and blunter than the upper ones. Some species of the section *Crepidium*, especially those from Borneo and the neighbouring islands, are remarkable for the beautiful colouring of their leaves. *M. metallica* has its leaves, pseudobulb, and scape of a dark purple-red colour highly polished. In *M. calophylla* the centre of the leaf is olive-brown, and the edge bright green with transverse streaks of olive-brown.

The scape is usually erect and slender, often angled and shortly winged; the lower part (usually from a third to a half) is nude, and above the flowers are arranged in a lax or compact raceme or spike, or, as in the section *Umbellulatæ*, in an umbel at the top of an entirely nude stem. In the section *Pedilæa* the pedicels are very short; so that the flowers are almost sessile, and are densely crowded into a slender cylindrical spike. In the South-American Dienias and the Crepidiums the pedicels are usually slender and elongate, the flowers fewer and more distant. The bracts are almost always shorter than the pedicels, very rarely equal to them in length, and usually very much shorter. They are persistent, and often become deflexed after flowering.

The flowers are always small, and often minute, very seldom more than ½ an inch across, and usually numerous. The largest are those of *M. tipuloidea* and *M. Josephiana*. The lip is always uppermost in the genus, owing to the fact that the pedicel and ovary are not twisted, but retain the normal position. In *Liparis* this position of the flowers is rare, and is almost exclusively confined to the section *Platystylis*, which, it is interesting to note, has also a short and thick column. I do not, however, think that this section is closely allied to *Microstylis*, but am rather inclined to consider this correlation, *i. e.* of the lip uppermost with a short column, to bear some relation to fertilization.

The colour of the flowers is commonly green, but yellow, livid, purple, and dark-crimson flowers also occur, especially in the section *Crepidium*. Perhaps the showiest are those of *Microstylis Rheedii*, in which they are of a dark but translucent crimson. In *M. versicolor* and *M. discolor* the flowers, on opening, are bright yellow, becoming bright red on withering.

The sepals are usually broader than the petals, very rarely a little narrower, oblong or oblong-lanceolate or ovate, blunt, and, like the petals, with revolute margins. The two lateral sepals are often falcate and oblique, and then usually much broader than the dorsal one. They are in this case opposed to and often longer than the lip, and are very liable to become connate for a longer or shorter distance. The petals are narrow linear, and, like the sepals, usually spreading or abruptly recurved. The lip is ovate or ovate-lanceolate, orbicular, or sometimes oblong, entire, or lobed, or (in the *Rheedii* group) laciniate. In a large number of species the hind margins are prolonged behind into longer or shorter lobes (auricles), which in some cases meet behind, so that the column appears to emerge from the centre of a circular lip. In almost all the species there is a shallow depression, the fovea, which appears to be a source of attraction to the fertilizers. Three veins, which are usually conspicuously thickened, run divergently from the base of the lip. In the Dienias two of these either form the edge of the fovea or run just inside of it, while the third traverses the centre, disappearing at the end of the fovea. In some of the Crepidiums the two lateral veins only are observable; they run on either side of the fovea, arising from a basal callus, which is often bifid, showing its double origin (*M. versicolor* &c.).

The column is usually very short and thick; rarely, as in *M. versicolor*, it is more elongate, narrowed at the base. The stelidia or column-wings are either short acute teeth or broader blunt lobes. They are frequently, in the section *Crepidium*, coloured bright emerald-green, forming a contrast with the purple lip. The anther-cap is depressed conical, with a short beak in front. It is somewhat firmly attached to the filament, so that it is commonly present in herbarium specimens, which is not the case in *Liparis*, where the anther-cap is almost or quite free when the flower is open. It is quite possible that this firmer attachment in *Microstylis* may bear some relation to the position of the flowers; for if the anther-cap were free in flowers with the lip uppermost, it would run a great risk of falling off at once on the opening of the flower, and carrying the pollinia with it.

The pollinia are four in number, oval, attached by the apex, but without any gland or caudicle. The stigma is small and oval or almost semilunar, and shallow.

The ovary is six-ribbed, the sterile valves being usually narrower and more projecting than the fertile ones. In *M. myurus* and some others the ribs are sinuate and knobbed in the fruit, but not in the flower; while in *M. congesta* the sinuation visible in the young ovary disappears as the fruit ripens. The capsule is oblong or elliptic oblong in outline, very similar to that of *Liparis*. During fruiting the pedicel thickens, and often elongates. The fruit always remains erect, and does not curve downwards as in some of the Liparids.

Fertilization.—There seems to be less variation in the attractions for the fertilizers in *Microstylis* than in *Liparis*. The base of the lip is depressed, as has been stated, and the three veins which run from the base respectively form the margins and traverse the centre. These I have sometimes found nibbled across as if by some insect, and are evidently the attraction. In a few species there is a callus at the starting-point of the veins, which probably also proves attractive.

The only observation I have seen recorded as to the fertilization of any species in the genus is that of Prof. Barbosa Rodrigues (Gen. et Sp. Nov. Orch. i. p. 29), where he says of his *Cheiropterocephalus sertuliferus* (*Microstylis histionantha*), "L'anthère lors de l'anthère est douée d'un mouvement qui la redresse et fait que les pollinies sont éjaculées sur le stigmatie." If this be commonly the case in this species, it must be self-fertilized. The pollinia in most cases fall out very readily; but as the flower is resupinate, it would fall away from the stigma towards the back of the column. Darwin, however, when treating of *Malaxis* *, makes a few remarks on the structure of "*M. Rheedii*" from India (probably *M. versicolor*), and shows that *Malaxis*, the habit of which is so similar to *Microstylis* of the *Dienia* section, is always and readily fertilized by insects.

Distribution.—The genus, as has been already said, is almost as widely distributed as *Liparis*; but it is not so abundant. There is a single species in Europe, which extends all through the north temperate zone. In the African region only two closely allied and peculiar species are known—one from Prince's Island, the other from the Comoro Islands. None are yet known from Madagascar, so rich in species of *Liparis*. The Indo-Malayan region contains a large number of species, two of which extend respectively as far as Afghanistan and Australia. There are three or four in the Polynesian Islands. In America there are a considerable number, including the whole sections of *Umbellulatæ*, *Pedilæa*, and the 1-leaved Dienias. The larger number come from Central America.

Divisions.—As the typical form of *Microstylis* may be taken *M. monophyllos*, a species of the widest distribution, occurring in both hemispheres. From some such species as this, with its raceme of minute green flowers and usually single leaf, the Dienias of South America may be derived. Some of these have long capillary pedicels to the flower, which in *M. ophioglossoides* of North America show a tendency to become congested at the apex of the scape. This modification attains its greatest development in the *Umbellulatæ*, in which the rhachis is much shortened and the pedicels so much equalized in length, that at first sight the inflorescence seems to form a true umbel. In the group represented by *M. Massonii* the pedicels are long and slender, and the flowers are crowded towards the end of the raceme, rather densely so as to form a kind of head; but the rhachis is not shortened, and the flowers are larger and more rounded in outline than in the Dienias. In *M. gracilis* of the *Dienia* section the flowers are almost sessile, with short thick ovaries and pedicels. This seems almost a connecting-link with the curious section *Pedilæa*, in which the flowers are almost sessile on a thickened rhachis, in which are depressions to receive the very short pedicel. The inflorescence is thus almost truly a spike, very dense, the flowers almost overlapping each other. Besides these sections there are in South America two remarkable species which seem to be allied to no other known forms, *M. caulescens* and *M. tipuloidea*. In the Old World, starting again from the *M. monophyllos* form, we have a number of species with small green flowers and few leaves; *M. muscifera* is an example. From these we may derive the section *Crepidium* of Blume, with numerous leaves, frequently oblique, and often fewer and larger showy flowers on longer pedicels, of which the true *M. Rheedii* is a typical form. *M. commelinifolia*, unaccountably referred by Mr. Bentham to *Platyclinis*, belongs to this section, as the form of its flowers shows, though its stem and leaves are quite peculiar. And allied to the same section are *M. cardiophylla* and *M. stelidostachya*, which again are aberrant both in their vegetative and floral organs.

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* Fertilis. Orch. p. 134.

MICROSTYLIS, *Nuttall*,

Gen. Amer. ii. p. 196; *Lindl. Orch. Pl.* p. 19; *Orch. Scelet.* no. 135; *Benth. Gen. Plant.* iii. p. 494.

Pterochilus, *Hook. & Arn. Bot. Beech. Voy.* p. 71, t. 17.
Dienia, *Lindl. Bot. Reg.* sub t. 825; *Orch. Pl.* p. 22.
Pedilea, *Lindl. Hook. Fl.* p. 115; *Orch. Scel.* no. 144, p. 27.
Crepidium, *Blume, Bijdr.* p. 387.
Achroanthes, *Rafin., fide Endl. Gen.* p. 189.
Malaxis sp., *auct. veter.*—Ophrys sp., *auct. vet.*
Monorchis, *Mentzel, Pug.* t. 5.

§ *Dieniæ Americanæ.*—Folium singulum.
Flores minimi dissiti in racemo longo, pedicellis longiusculis.
  Pedicelli capillacei 4 millim. longi.
    Flores virides.
      Folium ovatum cordatum.
        Labellum lanceolatum triangulare. 2. *maianthemifolia.*
        Labellum subtrilobum .... 3. *cordata.*

Folium cordato-oblongum .... 4. *ichthyorrhyncha.*
Folium ellipticum obtusum.
Labellum auriculatum .... 5. *arachnifera.*
Labellum exauriculatum .... 1. *monophyllos.*
Flores purpurei .... 6. *porphyrea.*
Pedicelli brevissimi vel subnulli, crassi .. 7. *gracilis.*

§ *Spicatæ.*—Flores majores versus apicem racemi congesti, nec umbellati; folia 2–1.
Sepala lateralia connata.
Labellum cordatum apiculatum ...... 9. *Warmingii.*
Labellum orbiculare undulatum ...... 8. *disepala.*
Sepala omnino libera.
Labellum ovatum cordatum .... 10. *floridana.*
hastatum angustum ...... 13. *Massonii.*
orbiculare reniforme marginibus sinuatis.
11. *rotundata.*
trilobum, lobo medio longiore. 12. *spicata.*

§ *Umbellulatæ.*—Scapus omnino nudus usque ad racemum brevissimum, flores in pedicellis longis corymbosi parvi virides.
Labellum integrum exauriculatum.
Labellum ovatum acuminatum.
Sepala labello vix longiora .... 20. *fastigiata.*
Sepala labello multo (*i. e.* 1 millim.) longiora.
21. *longisepala.*
Labellum obspathulatum .... 22. *corymbosa.*
Labellum integrum auriculatum,
ovatum acuminatum angustum hemisphæricum;
caulis in vagina ventricoso incluso.
23. *ventricosa.*
vagina ventricosa nulla. 24. *rupestris.*
ovale cordatum transversum . 25. *brachystachys.*
ovatum rotundatum,
glabrum; planta magna. 26. *histionantha.*
pubescens; planta minor.
27. *pubescens.*
rhomboideum; bracteæ longæ. 28. *crispifolia.*
oblongum; bracteæ breves .. 29. *andicola.*
lanceolatum efoveolatum .... 30. *Moritzii.*
Labellum apice trilobo.
Flores in scapum plus minus dissiti .. 14. *ophioglossoides.*

Flores vero corymbosi.
Lobus medius labelli multo longior .. 15. *umbellulata.*
Lobi omnes subæquales, breves.
Folia patula angusta acuminata ...... 16. *caracasana.*
Folia late ovata.
Labellum ambitu subquadratum.... 17. *hastilabia.*
ovatum acuminatum;
lineæ callosæ integræ. 18. *simillima.*
lineæ callosæ denticulatæ. 19. *lagotis.*

§ *Pedilæa.*—Flores in racemo densissimo ferme sessiles.
Labellum apice integro acuto.
Folium 1, ovatum.................. 31. *calycina.*
Folium 2, lanceolata................ 32. *myurus.*
Labellum apice bilobo .... 33. *macrostachya.*
Labellum apice trilobo, lobo mediano minuto .... 34. *montana.*

§ *Tipuloidea.*—Flores majores. Labellum ⅜ unciam longum. 35. *tipuloidea.*

§ *Caulescentes.*—Caulis elongatus undique foliatus repens. 36. *caulescens.*

Gerontogeæ.—Folia 1–2, oblonga.
Flores minimi, in racemo laxo breviter pedicellati.
Folium unum, raro 2, ovatum, flores aggregati .... 1. *monophyllos.*
Folia bina, lanceolata, flores laxi .... 37. *muscifera.*
Flores dense aggregati; labellum integrum .... 38. *cylindrostachya.*
Labellum bilobum .... 39. *Godefroyi.*
Folia plura congesta.
Flores minimi dense congesti, scapo infra nudo.
Labellum cymbiforme, apice trilobo. 40. *congesta.*
Labellum integrum auriculatum .. 41. *biaurita.*
Flores majores.
Labellum integrum ventricosum .. 42. *Josephiana.*
Labellum sagittatum acutum ...... 43. *Burbidgei.*
Labellum ovatum acutum .... 44. *discolor.*
Labellum bifidum.
Bracteæ pedicellis brevibus ferme æquantes. 46. *biloba.*
Pedicelli bracteis multo longiores .. 47. *Wallichii.*

Labellum trilobum.
Lobus medius integer.
Folia lata in apicem caulis congesta;
lanceolata .... 48. *carinata.*
ovata plicata .... 49. *oculata.*
Folia angustiora in caule dissita.... 50. *polyphylla.*
Lobus medius bifidus.
Caulis foliis dissitis tectus .... 51. *taurina.*
Folia in caulis crassi apicem congesta.
Flores purpurei .... 52. *purpurea.*
Flores virides vel flavi.
Lobus medianus labelli vix ullis longior.
53. *calophylla.*
Lobus medius multo longior .. 54. *chlorophrys.*
Labellum apice dentato.
Caulis subrepens; foliis dissitis nunquam bulbosus.
Flores magni rubri speciosi ...... 59. *Rheedii.*
Flores parvi flavescentes.......... 60. *bancana.*
Caulis pseudobulbosus.
Folia apice congesta viridia.
Flores flavi morientes rubri sub anthesi congesti .... 61. *versicolor.*
Flores dissiti aurantiaci.
Labellum trilobum .... 55. *segaarensis.*
Labellum non trilobum ...... 56. *Ventilabrum.*
Folia purpurea nitida .... 57. *metallica.*
Caulis pseudobulbosus ovalis parvus.
Folia e basi angusta erecta.
Scapus basi nudus.
Labellum dentatum bilobum ...... 62. *pratensis.*
Labellum dentatum integrum .... 63. *luteola.*
Labellum crenulatum .... 64. *crenulata.*
Scapus omnino racemosus.
Bracteæ patentes persistentes .... 65. *lancifolia.*
Caulis repens folia ovata petiolata undique tectus.
68. *commelinifolia.*

Africanæ.—Folia ovata petiolata pauca dissita; flores parvi rotundati.
Labellum integrum .... 66. *cardiophylla.*
Labellum bilobum .... 67. *stelidostachya.*

§ *Dienia.*

1. MICROSTYLIS MONOPHYLLOS, *Lindl. Orch. Pl.* p. 19; *Reichb. Ic. Flor. Germ.* xiii. p. 163; *Regel, Ind. Sem. Hort. Petrop.* 1878, p. 18; *Gray, Manual Bot.* ed. 5, p. 509; *Torrey & Gray, Fl. N. York*, p. 268; *Irmisch, in Flora*, 1863, p. 2.—M. diphyllos, *Lindley, Orch. Pl.* p. 19; *Regel, Ind. Sem. Hort. Petrop.* 1868, p. 79.—M. brachypoda, *Asa Gray, in Ann. Lyc. New York*, iii. p. 228.—M. Gmelini, *Lindl. Orch. Pl.* p. 11.—Ophrys monophyllos, *Linn. Sp. Pl.* ed. i. p. 947.—O. μονόφυλλος bulbosa, *Loesel. Fr. Pruss.* ed. 1703, p. 180, t. 57.—O. latifolia, *Linn. Fl. Suec.* ed. ii. p. 316. n. 811.—O. lilifolia, *Linn. Sp. Pl.* ed. i. p. 946.—O. scapo nudo etc., *Ehret, in Phil. Trans.* liii. (1764) p. 81, t. 4.—Epipactis folio unico etc., *Hall. Hist. Stirp. Helv.* p. 151, t. 38.—E. monophyllos, *F. W. Schmidt, in Meyer, Phys. Aufs.* 1791, p. 245, t. iii.—Malaxis monophylla, *Swartz, Fl. Ind. Occ.* p. 1443; *Stockh. Nya Handl.* xxi. 1800, p. 234; *Gen. & Sp. Orch.* p. 69; *Willd. Sp. Pl.* iv. p. 90; *Wahlenb. Fl. Suec.* ii. p. 561.—M. diphyllos, *Cham. in Linnæa*, iii. p. 34.—Monorchis ophioglossoides, *Mentzel, Pugil.* t. 5. fig. 2.

Rhizoma breviter repens, pseudobulbus ovatus, vaginis laxis membranaceis albescentibus tectus, $\frac{1}{2}$-uncialis; folium singulum raro bina, ovatum ellipticum obtusum flaccidum, 2 uncias longum, $\frac{3}{4}$ unciam latum; scapus gracilis angulatus, 3–6-uncialis, dimidio nudo; flores minuti virides copiosi, pedicellis $\frac{1}{8}$-uncialibus, bracteis lanceolatis acutis longioribus; sepala lanceolata obtusa; petala linearia angusta; labellum ovatum cuspidatum, marginibus nonnunquam crispulis, carnosulum, concavum, lineis medianis tribus, auriculis nullis, basi autem excavata; columna brevis crassiuscula, apice dilatato, clinandrio lato; anthera majuscula; stigma grande ovale; capsula elliptica oblonga erecta, $\frac{3}{16}$ unciam longa.

Europe: Norway, Sala, *Ahlberg*! *Sillen*! *Fries, Herb. Norm.* no. 62. Russia: Moscow, *Bieberstein*!; Ingria, *Meinetshausen, Fl. Ingr.* no. 627!; Shitomir, *Golde*!; Reval, *Russow*!; Dorpat, *Lehmann*!; Oesel, Heiligensee, *Lehmann*!; Chudleigh, *Gruner*! Switzerland: Lauterbrunnen, *Guthnick*!: Untersberg, *Hoppe*!; Neustadt, *Buchholz*!; Unterlichsberg, *Scholtz*! Tyrol, Lowenstein Mt., *Roemer*!; Oetzmuhl-Oetz, *Auerswald*! Styria, *Grabmayr*!

Asia: Kamtschatka, Awatscha Bay, *Seemann*!

N. America: Michigan, Hubbardstown, *Wheeler & Smith*. Fairfield, Herkomer co., *Hadley*. Bridgewater, Oneida co.,

Gray & Bradley. New York, *Asa Gray*! Northumberland, W. Canada, *Macoun*!

2. MICROSTYLIS MAIANTHEMIFOLIA, *Reichb. f. in Linnæa*, xxii. p. 834.—Malaxis maianthemifolia, *Schlecht. & Cham. in Linnæa*, vi. p. 59.

Planta pusilla, caulis brevis uncialis, basi incrassata, vagina pallida membranacea lanceolata laxa tecta; folium singulum ovatum acutum cordatum patens, scapum amplectens, 1½ uncias longum, 1¼ uncias latum quo latissimum, margine pallido; scapus gracilis erectus, 4-uncialis, basi breviter nuda; racemus laxus multiflorus; flores minimi virides, pedicellis tenuibus, 4 mm. longis, suberectis; bracteæ lanceolatæ acuminatæ minimæ; sepalum posticum lanceolatum acutum, lateralia erecta lanceolata obliqua, plus minus connata viridia, linea mediana obscuriore; petala lanceolata, sepalis multo minora; labellum quam sepala brevius lanceolatum triangulare acuminatum acutum, basi latiore incrassata, fovea mediana, apice tenuiore, auriculis nullis.

Mexico, Xalapa, *Schiede*!

3. M. CORDATA, *Reichb. f. in Walp. Ann.* vi. p. 207.—Dienia cordata, *Lindl. Bot. Reg.* 1838, *Misc.* 124.

Pseudobulbus globoso-conicus brevis superne in caulem 3 uncialem attenuatus; folium singulum exacte cordatum acutum erectum tenue, 1½ uncias longum, 1¼ uncias latum; scapus gracilis erectus 7-uncialis ferme omnino floriferus; flores copiosi parvi, virides; pedicelli tenues ¼-unciales; bracteæ minutæ lanceolatæ acuminatæ acutæ erectæ nec deflexæ; sepalum posticum lanceolatum subobtusum, ⅛-unciale, lateralia latiora ovato-lanceolata; petala linearia angusta; labellum subtrilobum, basi lata exauriculata, lobi laterales rotundatæ, medio longiore lanceolato, subobtuso, sepalis lateralibus ferme æquale; fovea haud profunda costa elevata antice; columna brevis, stelidia minima.

Mexico, *Barker*!

4. M. ICHTHIORRHYNCHA, *Reichb. f. Beitr. zur Orch. kunde*, p. 99.—Malaxis ichthiorhyncha, *Rich. & Gal. in Ann. Sc. Nat.* 1845, p. 18.—? Microstylis cochlearifolia, *Reichb. f. in Linnæa*, xxii. p. 804.—Malaxis cochlearifolia, *Rich. & Gal. l. c.*

Caulis gracilis monophyllos, 1½-3-pollicaris; folium sessile ultra unciam longum cordatum, unciam latum, oblongum acutum; racemus elongatus, basi dimidio nudus laxiusculus; flores albi, iis *M. monophylli* paullo majores; bracteæ minutissimæ triangulæ ovariis longe pedicellatis longe breviores; sepalum posticum tri-

angulum angustum; sepala lateralia connata varie fissa binervia; petala a latiore basi lineari-ligulata uninervia; labellum sagittatum oblongum triangulum, linea callosa marginante ante apicem incurrente.

Huatusco, *Richard.* Costa Rica, Volcano de Barba, *Wendland.*

I do not know this species, which seems to be closely allied to *M. maianthemifolia*, but differing in the shape of its leaf, which is ovate and acute in the latter. The value of the connation of the two lateral sepals I am not certain of; it is apparently irregular in amount in this species, and I expect is really abnormal.

5. **Microstylis arachnifera**, n. sp.

Caulis 3-uncialis, gracilis, basi vix incrassata; folium singulum suberectum basi amplectens lanceolatum obtusum, 2 uncias longum, ½ unciam latum; scapus debilis, 4–6-uncialis, angulatus, basi brevi nuda, superne laxe racemosus; flores minimi copiosi dissiti virides; pedicelli tenues 4 mm.; bracteæ minimæ lanceolatæ; sepala linearia angusta acuta; petala angustissima linearia breviora; labellum hastatum acutum, auriculis majusculis rotundatis; fovea nulla, lineis medianis 1–3; columna pro flore grandiuscula; anthera majuscula oblonga.

Mexico, *Capt. Lyon*! Sierra Madre, N.W. of Mexico, *Seemann*, 1957!

6. **M. porphyrea.**—M. purpurea, *S. Wats. in Proc. Amer. Acad.* xviii. 1883, p. 195; *Contrib. to Amer. Bot.* xi. p. 195 (*non Lindl.*).

Caulis 5-uncialis, basi paullo pseudobulbosa, vaginis obtusis purpurascentibus, tectus; folium singulum oblongum vel ovatum oblongum, acutiusculum, 3 uncias longum, 1¾ uncias latum; scapus basi ⅓ nuda, superne laxe racemosus, 7–9-uncialis; flores minimi purpurei, pedicellis gracilibus, 1–1½ lineas longis; sepala linearia oblonga, 1½ lineas longa; petala angustiora linearia breviora; labellum hastatum triangulatum acuminatum, fovea nulla, basi concava, linea elevata in medio; auriculis minimis rotundatis; columna grandiuscula, stelidiis obtusis rotundatis; capsula rotundata ovata, 2 lineas longa, suberecta.

S. Arizona, Tanner's Cañon, Huachuca Mountains, *Lemmon*, no. 2881! Dr. Sereno Watson very kindly sent me a drawing and flowers of this plant.

It is quite possible that this plant may be the species intended by Prof. Reichenbach under the name of *M. Ehrenbergii.* His description, however, is insufficient to identify it with certainty, and I am unwilling to unite the two. *M. Ehrenbergii* is described as having a "labellum oblongum acutum . . . . . gibbere acuto in media parte basilari." *M. porphyrea* has no distinct fovea; the lip is concave at the base, but not saccate, as in some other species.

I quote the description of *M. Ehrenbergii* for comparison.—

"*M. Ehrenbergii*, Reichb. f. in Linnæa, xxii. p. 835.—Caulis basi vaginatus, medio monophyllo; folium oblongum, basi et apice attenuatum; racemus plurimiflorus; bracteæ ovatæ seu oblongæ acutæ 1–3-nerviæ, pedicellis breviores; flores postici, atro-purpurei; sepala oblonga acuta; petala linearia; labellum oblongum acutum, basi dilatatum ima basi biaurito; auriculis minimis nunc obsoletis, gibbere acuto in medio parte basilari.

"Mexico, Real del Monte, *Ehrenberg*."

7. MICROSTYLIS GRACILIS, n. sp.

Caulis gracilis, 3-uncialis; folium singulum erectum oblongum, 1½ uncias longum, ¾ unciam latum; scapus 4-uncialis, dimidio nudo, gracilis; flores minimi dissiti, pedicellis circiter 1 mm. longi; bracteæ lanceolatæ brevissimæ, pedicellis æquales; sepala ovata acuta, posticum quam lateralia majus; petala linearia acuminata; labellum sepalis brevius ovata cuspidata subacuta, fovea majuscula nec profunda auriculis subnullis; columna brevissima, stelidiis dentiformibus.

Guatemala, Amazola and Tinula, at 1700 feet, 14th July, 1882, *Lehmann*, no. 1846! Very rare. In Herb. Brit. Mus.

§ *Spicatæ*.

8. M. DISEPALA, *Reichb. f. in Linnæa*, xxvi. p. 142.

Caulis cylindraceus, pseudobulbosus pollicaris, vaginis membranaceis oblongo-triangulis vestitus; folia evoluta bina e vaginis linearibus in laminas orbiculares acutas dilatata; scapus elongatus 7-pollicaris angulatus, apice clavato racemoso; bracteæ lineari-lanceolatæ brevissimæ; pedicelli elongati; flores colore terreno; sepalum posticum lanceum triangulum obtusiusculum, lateralia connata oblonga, apice bidentato; petala linearia circinnata; labellum orbiculare, basi obtusissime cordatum, margine obsoletissime undulato lobulato, basi foveata; columna minuta, rostello tridentato.

Venezuela, near Curucuti, 2000–3000 feet alt., *Wagener*, no. 134.

This seems to be very near *M. rotundata*, but apart from the connate lateral sepals, which may be accidental, the petals in that

species are spathulate and not linear, and the single sepal is ovate and not lanceate triangular.

9. **Microstylis Warmingii**, *Reichb. f. Otia Hamb.* p. 94; *Warming, Aftr. Vidensk. Meddel. Nat. Foren.* 1883, p. 843, t. iv. fig. 5.

Prope bipedalis; folia ad 6 inæqualia usque 2 pollices lata, 3½ longa, petiolata elliptica obtusiuscula, sicca subcuprea; scapus 7-angulatus, omnino supra folia usque ad inflorescentiam nudus; racemus amplus congestus, 3-uncialis; bracteæ semilanceæ, uninerves, pedicellis subæquantes; sepalum posticum oblongum lanceolatum subobtusum, marginibus revolutis; lateralia falcata obtusa (ex icone), basi connata (an semper?) labellum multo superantia; petala linearia angusta; labellum cordatum apiculatum subobtusum, auriculis brevibus latis rotundatis, fovea distincta; columna brevis, dentibus brevibus acutis.

Brazil, Lagoa Santa, *Warming.*

10. M. **floridana**, *Chapman, Fl. S. Un. States*, p. 454.

Caulis gracilis, 3-uncialis, basi serius incrassata; folia bina dissita ovata vel elliptica petiolata, subacuta, inæqualia suberecta, lamina maximi, 2 uncias longa, unciam lata; petiolus 1–1⅔ uncias longa; scapus gracilis ad 8 uncias longus, basi longe nuda; racemus laxus; flores plures parvi; bracteæ lanceolatæ acutæ; pedicelli tenues ¼-unciales, suberecti patuli; sepala lanceolata oblonga, patentia marginibus revolutis; petala linearia torta; labellum ovatum cordatum abrupte apiculatum; auriculis rotundatis curvis obtusis; fovea rotundata majuscula depressa; columna brevis; capsula oblonga elliptica suberecta, ¼ unciam longa.

North America, Apalachicola, Florida!

I have to thank Dr. S. Watson for sending me a tracing and flowers of this very rare plant.

11. M. **rotundata**, n. sp.

Caulis gracilis, 1½ uncias longa, basi pseudobulbosa incrassata, ½ unciam longa; folia bina valde inæqualia ovata cuspidata breviter petiolata, reticulata, maximum 1½ uncias longum et latum; scapus erectus, 6-uncialis, basi longe nuda, apice racemoso; flores plures parvi, ¼ unciam lati, verosimiliter flavescentes, pedicellis gracilibus ¼-uncialibus; bracteæ minimæ lanceolatæ subacutæ, vix ¼ pedicelli æquales; sepalum posticum late ovatum obtusum, lateralia angustiora obtusa; petala his ferme æqualia subspathulata obtusa; labellum late rotundatum reniforme crenulatum obtusum fovea depressa rhomboidea; columna grandiuscula.

Guadeloupe?, *Richard*! Herb. Brit. Mus.

A single specimen from Richard's collection without locality is all that I have seen. Some other Orchids from the same collector and with similar tickets came from Guadeloupe.

12. Microstylis spicata, *Lindl. Gen. & Sp. Orch. Pl.* p. 19; *Griseb. Fl. Brit. West Indies*, p. 612.—Malaxis spicata, *Swartz, Prodr.* 49; *Flora Ind. Occ.* p. 1441, t. 28. f. *a, b, c*; *Lunan, Hort. Jamaica*, i. 478.

Caulis 4-uncialis, basi incrassata, vagina membranacea singula tecto; folia bina inæqualia, alterna longe (unciam) dissita ovata vel ovato-lanceolata acuta, vaginantia scapum amplectentia haud petiolata, inferius maximum 3 uncias longum, 1⅓ latum; scapus 5–9-uncialis, basi longe nuda; racemus laxus vel laxiusculus 2-uncialis pluriflores; flores parvi plures virides, pedicellis suberectis ¼-uncialibus; bracteæ minimæ lanceolatæ setaceæ, pedicelli ⅓ vix æquales; sepalum posticum lanceolatum ovatum acutum, lateralia lanceolata obtusa; petala linearia breviora; labellum cordatum trilobum, lobi laterales rotundati subobtusi, medius longior acutus, auriculi breves obtusissimi rotundati, fovea distincta profunda subtus vix gibbosa; anthera omnino biloculata; apiculis duobus minutus ad margines interiores loculorum; rostellum latum vix trilobum.

Jamaica, *Swartz*! Westmoreland Mountains, *Purdie*! Cuba, *Wright*, no. 1696, 3304.

13. M. Massonii, n. sp.

Rhizoma validulum diu repens; caulis gracilis, 4-uncialis, basi incrassata; folia bina dissita, inferius majus, late ovata subobtusa petiolata, 3 uncias longa, 2¼ uncias lata; petiolus subpatulus uncialis in vagina unciali inferne desinens; scapus validulus erectus subteres, 9-uncialis, basi longe nuda; racemus compactus 2-uncialis; flores plures parvi, pedicellis suberectis semiuncialibus; bracteæ lanceolatæ acuminatæ brevissimæ; sepalum posticum late lanceolatum subobtusum, lateralia angustiora lanceolata lorata deflexa; petala angusta linearia; labellum hastatum acutum, auriculis majusculis rotundatis obtusis; columna majuscula, rostello magno.

W. Indies, St. Christopher's, *Masson*! Dominica, *Imray*! Trinidad, *Crueger*!

§ *Umbellulatæ.*

14. MICROSTYLIS OPHIOGLOSSOIDES, *Nuttall, Genera Amer. Pl.* ii. p. 196; *Lindl. Orch. Pl.* p. 19; *Chapman, Fl. S. Un. States*, p. 453.—Malaxis unifolia, *Michaux, Fl. Bor. Am.* ii. p. 157.—M. ophioglossoides, *Willd. Sp. Pl.* iv. p. 90; *Loddiges, Bot. Cab.* t. 1116.

Caulis 2–5 uncias longus, basi pseudobulbosus, pseudobulbo parvo globoso-conico; vaginis duabus, superiore majore circiter dimidio caulis æquali; folium singulum ovatum ellipticum obtusum, amplexicaule subpatulum, 1½–3 uncias longum unciam latum; scapus erectus vel subnutans gracilis angulatus, 3-uncialis, majore parte racemosus; racemus demum laxus multiflorus; flores parvi virides, pedicellis tenuibus patulis vel recurvis, ½-uncialibus; bracteæ brevissimæ lanceolatæ, 1 mm. longæ; sepala lanceolata subobtusa, lateralia latiora obliqua, labello æquales; petala angusta linearia; labellum oblongum, apice trilobo, lobis lateralibus majoribus lanceolatis obtusis, medio multo minore, cuspidiformi acuto, venis medianis incrassatis, basi vix concava, auriculis nullis; columna basi paullo angustata, apice dilatato, dentibus brevis; anthera majuscula, stigma ovale grande; capsula elliptica ¼-uncialis.

North America: Canada, Rainy Lake and River (*Dr. Richardson*)!; Lake Region and Ontario (*Macoun*)!; Pembina, Winnipeg (*Bourgeau*)!; Newfoundland (*Morrison*)!; Massachusetts, New Jersey (*Nuttall*)!; Maine (*Torrey*)!; Philadelphia (*Gavin Watson*)!; S. Carolina (*Cree*)!; Vermont (*Pringle*)!; Ball Mountains, Tennessee (*Rugel*)!; Florida (*Chapman*)!

Mexico: San Luis Potosi (*Parry & Palmer*), no. 859!

15. M. UMBELLULATA, *Lindl. Orch. Pl.* p. 19; *Griseb. Flor. Brit. West Ind.* p. 612.—Malaxis umbellulata, *Swartz, Prodr.* p. 119; *Flor. Ind. Occ.* p. 1444; *Willd. Sp. Pl.* iv. p. 90.—M. umbelliflora, *Lunan, Hort. Jamaica*, i. p. 478.

Caulis 3-uncialis, gracilis, basi pseudobulbosus radicibus crebris; folia bina valde inæqualia membranacea reticulata lanceolata acuminata, maximum 4 uncias longum, 2 uncias latum; scapus gracilis angulatus (pentagonus *fide Swartz*), apice nutante, 6 uncias longus; racemus brevissimus circiter dimidio unciam longus; bracteæ setaceæ, ⅛ unciam longæ; flores virides? minuti, 3 vel 4 modo simul evoluti, pedicellis patulis tenuissimis ½ unciam longis; sepala angusta, ligulata, obtusa; petala multo breviora; labellum trilobum, lobis lateralibus brevibus rotundatis obtusis, medio lineari longiore angusto obtuso.

Jamaica, *Swartz*! *Macfadyen*! Dominica, *Eggers*!

16. MICROSTYLIS CARACASANA, *Klotsch, ined.*

Rhizoma longum, pseudobulbis dissitis clavatis; caulis gracilis, 3-uncialis; folia bina subopposita æqualia angusta lanceolata acuminata, marginibus crispis basibus vaginantibus 1½ uncias longa vix ½ unciam lata; scapus gracilis, 4½-uncialis; umbella brevis compacta; bracteæ breves lanceolatæ; flores minimi tenues, pedicellis ¼-uncialibus; sepala late lanceolata obtusa; petala angusta linearia; labellum oblongum quadratum, apice trilaciniato, laciniis subæqualibus obtusis; auriculæ longæ lanceolatæ acutæ, fovea magna costa mediana, haud multo elevata.

Columbia, *Karsten*! in herb. Brit. Mus.

17. M. HASTILABIA, *Reichb. f. Beitr. Orch. Centr.-Amer.* p. 101.

Planta sæpe validula habitus *M. Parthoni.* Pseudobulbi conici angusti unciales; caulis gracilis, basi vix incrassata, 4-uncialis, vagina singula 1¼ unciam; folia ferme opposita rarius spatio intermedio, ovata acuta, 3 uncias longa, 1½ uncias lata; scapus paullo alatus, 4–8-uncialis; umbella compacta, ½ unciam longa; bracteæ lanceolatæ triangulares acutæ; pedicelli graciles ¼-unciales; flores parvæ copiosæ; sepala lanceolata obtusa, lateralia quam labellum multo longiora; petala angusta linearia; labellum hastatum tricuspidatum, auriculis magnis divergentibus subobtusis, lamina versus apicem angustata, laciniis tribus brevibus subæqualibus, fovea elliptica longiuscula, marginibus incrassatis, linea elevata mediana centrali.

Tocota, *Lehmann*! Guatemala, *Lehmann*! Brazil, common in dry leafy woods of S. Paulo, *Bowie & Cunningham*! Organ Mountains, *Miers*!

18. M. SIMILLIMA, *Reichb. f. Beitr. Orch. Centr.-Amer.* p. 101.

Planta pedalis; folia bina cuneato-oblonga acuminata, quinque pollices longa, subopposita; scapus bene exsertus; umbella ultra pollicaris; bracteæ ligulatæ acutæ uninerviæ; sepala ligulata; petala filiformia; labellum concavum ovatum acuminatum, denticulo utrinque ante cuspidem superaddito, lineis callosis evanidis juxta limbum, disco omnino lævi.

Costa Rica, Desengano, *Wendland.*

19. M. LAGOTIS, *Reichb. f. Orch. Beitr. Centr.-Amer.* p. 101.

Pedalis, pseudobulbi turbinati seriati in sympodio persistenti;

caulis basi vaginis paucis vestitus, 3-4 uncias longum; folia 2, petiolata vel sessilia ovata, basi late cuneata vel rotundata acuminata, subopposita, 5 uncias longa, 3 uncias lata; scapus angulatus; flores virides; bracteæ triangulo-acuminatæ; sepala ligulata trinervia; petala lineari filiformia, quinquenervia; labellum subcordatum ovatum, apice tridentatum, carina crassa denticulata utrinque juxta limbum; carina integerrima interjecta.

Costa Rica, Volcan de Barba, *Wendland*.

MICROSTYLIS EXCAVATA, *Lindl. Bot. Reg.* 1838, *Misc.* 93, apparently belongs to this series; but neither the description nor the specimen preserved are sufficient for identification. It came from America.

20. M. FASTIGIATA, *Reichb. f. in Linnæa*, xxv. p. 834, xxviii. p. 384.—M. ophioglossoides, *Bot. Reg.* t. 1290; *Link & Otto, Ic. Pl. Rar.* iii. t. 5 (*non Nutt.*).—Malaxis maianthemifolia, *Rich. & Gal. in Ann. Sc. Nat.* 1845, p. 18; *non Schlecht.*—Dienia maianthemifolia, *Reichb. f. in Linnæa*, xix. p. 368.—Ophrys ensifolia, *Pavon, MSS.*

Caulis gracilis, 3-uncialis, basi pseudobulbosa, vaginis 2-3 pseudobulbo globoso annotino approximato; folia bina subæqualia lanceolata ovata obtusa 2 uncias longa, 1 unciam lata, basi amplexicaulia, vaginis brevibus, dissita; scapus 3-7-uncialis, angulatus apice nutante; racemus ½-uncialis, multiflorus; bracteæ brevissimæ lanceolatæ; flores minimi virides?, pedicellis gracillimis cum ovariis ½-uncialibus; sepala ligulata lorata; petala angustiora breviora; labellum sepalis æquale, obspathulatum cochleariforme, basi ovata concava, linea mediana elevata in gibbo desinente, auriculis subnullis, apice acuto lineari semitereti.

Mexico (*Pavon*)! (*Capt. Lyon*)! Vallée de Mejico (*Schmidt*)! (*Schaffner*)! (*Bourgeau* 652)! Jalapa, Serra Colorado (*Schiede*)! Cordillera Oaxaca (*Galeotti*)! no. 5059! (*Sallé*)! Caraco Mountain, Coahuila (*Palmer*), no. 1300!

Santa Martha (*Purdie*).

Bolivia, Sorata (*Mandon*), no. 1135!

The figure of the complete plant in Bot. Reg. 1296 is apparently *M. fastigiata*, the lip of the flower being represented as ovate, entire, and acute; but by the side of it is an enlarged drawing of a flower with a lip exactly similar to that of *M. ophioglossoides*, oblong and 3-lobed.

The plants quoted from Pavon and Capt. Lyon differ somewhat from the common typical form of *fastigiata* in their narrower leaves generally a little distant from each other and in the more slender pedicels, and possibly they may form a distinct species. But the flowers seem to be quite identical, and I am unwilling to give fresh names to plants so dubiously distinct. A specimen from the neighbourhood of Mexico, collected by Schmidt, has the lowest bracts unusually long and lanceolate acuminate, one nearly ¼ inch in length.

21. MICROSTYLIS LONGISEPALA, n. sp.

Caulis gracilis 6-uncialis; folia ovata obtusa, 3 uncias longa, 1½ uncias lata, dissita; scapus 6-uncialis validulus paullisper marginatus; umbella ½-uncialis; flores pro sectione majusculi virides, pedicellis ½-uncialibus capillaceis; bracteæ brevissimæ ovatæ lanceolatæ; sepala lanceolata obtusa, marginibus revolutis, 4 mm. longa; petala angusta linearia; labellum 3 mm. longum, ovatum acuminatum, acutum, basi saccatum, fovea ovata, marginibus carnosis, costa mediana elevata, auriculis nullis.

Mexico, Parada, near Oaxaca, *Sallé*! in Herb. Brit. Mus.

Very near *M. fastigiata*, especially the form collected by Pavon, but the flowers are larger, and the longer sepals are very conspicuous.

22. M. CORYMBOSA, *S. Wats. in Proc. Amer. Acad.* xviii. 1883, p. 195; *Contrib. Amer. Bot.* xi. p. 195.

Pseudobulbus globosus uncialis; caulis validulus 3-uncialis, vagina ampliata subacuta unciali ad basin; folium singulum ovatum subobtusum reticulatum amplexicaule 3 uncias longum, 2 uncias latum; scapus crassiusculus angulatus tres uncias longus; racemus vix uncialis; flores parvi, pedicellis ½-uncialibus gracilibus erectis, basi dilatata articulata; bracteæ minimæ lanceolatæ demum reflexæ; sepala angusta lanceolata acuminata acuta; petala angusta ligulata; labellum obspathulatum, basi plana late subquadrata, venis tribus obscurioribus in medio, apice angustata lanceolata acuminata acuta.

Arizona, Huachuca Mountains, *Lemmon*, 2882!

23. M. VENTRICOSA, *Poepp. & Endl. Nov. Gen. et Sp.* p. 8.

Rhizoma longa repens teres lignosum; caules erecti ascendentes incrassati tunica vel vagina integra modo superne fissa, e vaginis foliorum connatis exorta, basi valde clavata sensim

attenuata inflata ventricosa membranacea diaphana nervosa; folia ovato-oblonga acumine longo acutissimo, basi rotundata subtus acute carinata, carina valde prominente per vaginas decurrente, lamina seniorum 5 uncias longa, 1½ lata; scapus biuncialis; racemus ovalis subcylindricus, fructifer magis capitatus; pedicelli patuli infimi recti superioris erecti, quam ovarium duplo longiores, capsulæ æquales; bracteis subulatis; flores minuti virides iis *M. monophyllos* majores; perianthium eo *M. rupestris* similis labello ad apicem angustior; labellum subrotundum sagittatum hemisphæricum concavum, apice acuminato reflexo; capsula 5 lineas longa, ovalis.

Peru, Pampayaco, *Poeppig.*

24. MICROSTYLIS RUPESTRIS, *Poepp. & Endl. Nov. Gen. et Sp.* p. 8, pl. iii.

Pedalis et ultra; caulis subgracilis 8-uncialis, pseudobulbo ovali, nuclei cerasi magnitudine, vaginis membranaceis tecto; folia bina angusta, ovalia vel ovali-lanceolata subdissita, approximata, utrinque acuta, nitida, subtus acute carinata, sæpius valde inæqualia 2 uncias vel ultra longa, unciam lata; scapus erectus medio subcurvus pentagonus 8-uncialis; racemus hemisphærico-capitatus multiflorus uncialis; flores pro sectione majusculi flavidi resupinati, pedicellis erecto-ascendentibus capillaceis, ½-uncialibus, quam ovarium duplo vel triplo longiores; bracteæ minutæ subulatæ, ovato-lanceolatæ; sepala obliqua lanceolata acuta; petala filiformia, sepalis triplo angustiora; labellum hemisphæricum intus concavum, apice acuminata; auriculis minimis triangularibus; columna basi dilatata; capsula ovalis, 4 lineas longa, tricarinata.

Peru, Cassapi, *Poeppig*; Venezuela, Tovar, *Fendler*!

25. M. BRACHYSTACHYS, *Reichb. f. in Linnæa*, xxii. p. 834; *Walp. Ann.* iii. p. 26.

Caulis elongatus vaginatus monophyllus; folio ovali obtuso acuto, basi cordata, racemo brevissimo, densifloro fastigiato; bracteæ ovatæ acutæ; sepala oblonga obtusa; petala linearia obtusa; labellum ovale, basi cordata acuta transversa.

Mexico, Real del Monte, *Ehrenberg.*

The description of this species is hardly sufficient for so critical a section of the genus. Nevertheless it seems quite distinct in the shape of the lip from any other Mexican species known to me. It is probably allied to *M. corymbosa*, S. Wats.

26. **MICROSTYLIS HISTIONANTHA**, *Link & Otto, Ic. Pl. Rar. Hort. Berol.* t. 5; *Bot. Mag.* t. 4103; *Lindl. Bot. Reg.* xxvi. 1840, *Misc.* p. 214.—M. Parthoni, *Reichb. f. in Walp. Ann.* vi. p. 206; *Gard. Chron.* 1881, Oct. 8, p. 463; *Beitr. Orch. Centr.-Amer.* p. 59.—Malaxis Parthoni, *Morren, Bull. Acad. Roy. Brux.* 1839, p. 485.—Cheiropterocephalus sertuliferus, *Barb. Rodr. Gen. & Sp.* p. 28, *fide ejusd.*—Epidendrum umbellatum, *Velloz, Fl. Flum.* t. 23.

Planta validula, caule incrassato 4-unciali, pseudobulbo vetusto conico; folia bina subopposita late ovalia acuta patula 4 uncias longa 3 uncias lata, "glaucescentia viridia" (*Rodrigues*); scapus validulus 6-uncialis 4-angulatum; umbella globosa compacta multiflora; pedicelli vix ¼ unciam longi; flores parvi virides; sepala posticum reflexum, lateralia deflexa, omnia lanceolata obtusa; petala multo minora linearia acuta recurva; labellum integrum late ovatum subobtusum rotundatum, fovea haud profunda; columna crassiuscula.

Venezuela, Tovar, *Fendler* 1427! New Granada, Cholino near Rio de Huca, *Purdie*! Costa Rica, San José, *Wendland*. Nicaragua, *fide Reichenbach*.

Brazil, Rio de Janeiro, *Glaziou* 8033! Caldas and Picu, *Rodrigues*.

Var. **DENTICULATA**, *Reichb. f. Beitr. Orch. Centr.-Amer.* p. 100. Labellum minute denticulatum brunneum.

Costa Rica, Azari, *Wendland*.

27. **M. PUBESCENS**, *Lindl. in Hook. Journ. Bot.* ii. p. 662.

Caulis gracilis uncialis vix incrassatus; folia bina lanceolata acuminata suberecta tenuia nonnunquam ovato-lanceolata; petiolo vaginante 2½ uncias longo, ¾ unciam lato; scapus gracilis, 3½ uncias longus, angustatus; umbella parva compacta; flores minimi pedicellis brevibus vix ¼-uncialibus; bracteæ minutæ, ovatæ; sepala late ovata obtusa; petala angusta linearia; labellum rotundatum latum pubescens obtusissimum planum, fovea obsoleta, auriculis brevibus, latis obtusis.

Brazil, Organ Mountains, *Gardner* 674! *Miers*!

28. **M. CRISPIFOLIA**, *Reichb. f. Orch. Centr.-Amer.* p. 100.

Planta habitus *M. ventricosæ*, Poepp., 4–6 uncias alta; folia usque ultra biuncialia, petiolis liberis, laminis oblongis acuminatis crispulis, reticulatis nervulis transversis in siccis bene prominulis; scapus angulatus; bracteæ lineari-setaceæ, ovarii pedicellati dimidio subæquantes; labellum a basi rotundato-rhombeum, angulis posticis in cornua falcata extensis antice acuminato, linea limbosa ante apicem labellum transeunte.

Costa Rica, Desengano, *Wendland*.

29. Microstylis andicola, n. sp.

Caulis validulus, basi incrassata, conica, vagina laxa tectus 4-uncialis, radicibus longis lanatis; folia bina reticulata ovata amplexicaulia subacuta remotiuscula subæqualia, 2½–3 uncias longa, 1½ uncias lata; scapus strictus angulatus validulus 6-uncialis; umbella compacta ⅛-uncialis multiflora; flores parvi virides; pedicelli cum ovariis ferme ½-unciales; bracteæ ovatæ minimæ; sepala lanceolata subobtusa, posticum 4 mm. longum; petala angusta linearia quam sepala breviora; labellum basi saccato-hastatum oblongum obtusissimum, sepalis haud multo brevius, fovea profunda oblonga costa crassa mediana, marginibus incrassatis, auriculæ erecto-recurvæ longiusculæ lanceolatæ acutæ.

Ecuador: Mt. Pichincha, among shrubs at 11000 feet alt., *Jameson* no. 450!

The lip has the outline of *M. hastilabia*, but the apex is quite entire and blunt.

30. M. Moritzii, n. sp.

Rhizoma longiusculum validulum; caulis gracilis viridis, 3-uncialis, basi vix incrassata; pseudobulbus conicus, 1½ uncias longus, vagina albescente tectus; folia bina ovata petiolata acuta patula subopposita subæqualia, 2½ uncias longa, 1½ uncias lata, petiolus ¼-uncialis; scapus gracilis, 3-uncialis; umbella parva congesta; flores plures virescentes minimi; bracteæ pallidæ lanceolatæ acuminatæ angustæ; pedicelli ⅓-unciales; sepala ovata lanceolata obtusa tenuia; petala angustiora linearia; labellum quam sepala brevius lanceolatum angustum acuminatum excavatum, nec vero foveolatum, costa mediana carnosa; auriculæ recurvæ angustæ acutæ.

Venezuela: Tovar, in shady woods on damp ground in the subalpine region, Sept.–Oct., *Moritz* no. 1862! Herb. Brit. Mus.

The lip in this species is narrow and hollowed out, but there is no real fovea. The median vein is present, but the laterals are not visible. The flowers are very small, and the leaves are remarkably patent.

§ *Pedilæa.*

31. Microstylis calycina.—Dienia calycina, *Lindl. Orch. Pl.* p. 23.—Serapias parasitica, *Pavon MSS.*—Ophrys monophylla, *ejusd.*

Pseudobulbus ovoideus; caulis 4–7-uncialis, rectus, vagina laxa truncata breviter fissa ferme biunciali; folium singulum, ovatum, ferme obovatum obtusissimum vel ellipticum lanceolatum erectum amplexicaule, 3 uncias longum, unciam latum; scapus validulus subcylindricus, 6–12-uncialis, basi nuda; racemus in sectione laxissimus, multiflorus, rhachide articulata; flores minimi, rhachide appressi; bracteæ minutæ triangulari-ovatæ, acutæ, pedicellis brevibus crassis æquales; sepala ovata, subacuta, labello multo majora; petala linearia lanceolata, recurva, angusta; labellum brevissimum cordatum acutum, margine ad apicem incrassatum depressum; auriculis parvis obtusis; columna grandiuscula lata, stelidiis minutis acutis; capsula elliptica oblonga $\frac{1}{4}$-uncialis, costis vix elevatis haud sinuatis subæqualibus.

Mexico, *Pavon*! Vallée de Mejico, *Schmidt*!

Peru, *Pavon*! Guatemala, Camino del Lapote, *Bernouilli*, no. 327!

32. M. myurus, *Reichb. f. in Walp. Ann.* vi. p. 207.—Dienia myurus, *Lindl. Orch. Pl.* p. 23.—Pedilæa myurus, *Lindl. Orch. Scelet.* no. 144, p. 27.—D. crispata, *Lindl. in Ann. & Mag. Nat. Hist.* xv. 1845, p. 385.

Caulis circiter 4-uncialis, basi pseudobulbosa, vaginis fissis vetustis tecto, superne vagina laxa membranacea elongata; folia bina lanceolata obtusa, alterna erecta nec patula, 3 uncias longa vix unciam lata, subæqualia; scapus validulus, 7-uncialis, angulatus, basi longe nuda; racemus densus compactus, 3-uncialis, rhachide angulata, pedicelli breves crassiusculi articulati, bracteis parvis lanceolatis acuminatis vix longiores; flores parvi carnosuli; sepala lanceolata obtusa; petala angusta linearia; labellum cordatum apiculatum carnosum concavum, fovea majuscula obscura visa purpurea, linea mediana; ovarium crassum verrucosum sinuatis costis; capsula ferme matura $\frac{1}{8}$ unciam longa.

Mexico, *Pavon*! Vallée de Mejico, *Schmidt*!

33. M. macrostachya, *Lindl. Orch. Pl.* p. 21; *et in Benth. Pl. Hartw.* p. 52.—Ophrys macrostachya, *Llave, Nov. Veg. Mex.* 2, 9.—Malaxis densiflora, *Rich. & Gal. MS.*

Caulis 6-uncialis gracilis, basi incrassata conica, unciali;

vagina viridi truncata, 3-unciali; folium singulum ellipticum obtusum erectum amplexicaule, 5 uncias longum, $1\frac{3}{4}$ latum; scapus validulus 8-uncialis, dimidio inferiore nudo; racemus densus 5-uncialis; flores per parvi virides; bracteæ ovatæ lanceolatæ acuminatæ; sepalum posticum ellipticum lanceolatum obtusum, lateralia subæqualia paullo obliqua quam labellum breviora; petala linearia obtusa longiora; labellum tenue ovatum ellipticum; auriculis brevibus obtusis, apice retuso bilobo, lobis obtusis, venis quinque; columna basi angusta, apice dilatato, stelidiis brevibus obtusis truncatis.

Mexico: Mt. Campanario, near Anganguio, at 9000 feet altitude, *Hartweg* no. 395! San Felipe, Oaxaca, *Galeotti* no. 5053!

34. MICROSTYLIS MONTANA, *Rothrock*, *Reports on Geological Surveys*, 1878, *Botany*, p. 264.

Caulis gracilis, 3–$4\frac{1}{2}$-uncialis, basi subglobosa, fibris vaginarum vetustarum undique tectus; folium 1–2, ellipticum ovatum vel lanceolatum obtusum, 5-nervium, $1\frac{1}{2}$–3 uncias longum, $\frac{5}{16}$–1 unciam latum; scapus gracilis erectus, 4–9-uncialis, basi unciali nuda; racemus densus multiflorus; flores minuti, rhachide arcte approximati ferme sessiles, "flavescente-albi;" bracteæ ovales; sepalum posticum ovale ellipticum obtusum, lateralia subsimilia paullo obliqua, apicibus excurvis, labello subæquali vel paullisper breviora; petala angusta linearia; labellum ovale sagittatum, apice obtuso, sæpius emarginato subtrilobo, lobis lateralibus lanceolatis brevibus, medio minuto; auriculis brevibus obtusis; fovea lata, vix profunda; columna minuta, recta, stelidiis minutis acutis.

Arizona, Mt. Graham, at 9500 feet, *Rothrock*.

Mexico, near St. Luis Potosi, *Parry & Palmer*, no. 858! San Miguelito, *Schaffner* 517!

§ *Tipuloideæ*.

35. M. TIPULOIDEA, *Lindl. in Ann. & Mag. Nat. Hist.* xv. 1845, p. 256; *Reichb. f. Orch. Centr.-Am.* p. 162.

Subcaulescens; caulis $1\frac{1}{2}$ uncias longus, foliis dissitis 8, lanceolatis acutis, basi angustatis, 3 uncias longis, unciam latis, patulis tectus; scapus gracilis elongatus, circiter 27-uncialis ferme omnino laxe racemosus; flores plures, virides, majusculi remoti, pedicellis gracilibus semiuncialibus; bracteæ longæ angustæ lanceolatæ acuminatæ $\frac{3}{8}$-unciales; sepala lanceolata lorata, lateralia subfalcata; petala angusta linearia reflexa; labellum lanceolatum acuminatum, sepalis æquale, margine ciliato, ⅜ unciam longum, exauritum ?; columna brevissima.

Colombia, Popayan, *Hartweg*! Costa Rica, San Miguel, *Wendland.*

§ *Caulescentes.*

36. **Microstylis caulescens**, *Lindl. Bot. Reg.* 1841, sub t. 1.

Caulis haud bulbosus, repens longus, foliis undique tectus; folia lanceolata acuminata, marginibus crispis 2 uncias longa, ¼ lata; scapus ex axilla folii superioris ascendens angulatus, basi longe nuda; racemus elongatus laxus multiflorus; flores parvi virides haud resupinati, pedicellis brevibus, bracteas vix superantibus; bracteæ lanceatæ acuminatæ setaceæ, 4 mm. longæ, erectæ nec deflexæ; sepala lanceolata acuta pendula; petala linearia patentia; labellum lineam longum oblongum, apice obscure trilobo obtuso, auriculis brevibus rotundatis; fovea nulla ?; columna brevis crassa, stelidia brevia truncata; anthera depressa.

Ecuador, Lloa, at 8000 feet alt., *Jameson* no. 93! *Hall*!

§ *Dieniæ Gerontogeæ.*

37. **M. muscifera.** — Dienia muscifera, *Lindl. in Wall. Cat.* no. 1935; *Orch. Pl.* p. 23.

Planta in altitudine valde variabilis 4–12-uncialis; caulis sæpe gracilis, basi pseudobulbosa ovoidea, 1–5-uncialis, vaginis tectus; folia tenuia sæpissime 2, ovata subacuta vel ovato-lanceolata, rarius lanceolata, inæqualia, subremota, ad 2–3½ uncias longa, ¾–1½ uncias lata; scapus 2–7-uncialis vel ultra, vix dimidio nudus; racemus laxus multiflorus nutans gracilis; flores virides minimi iis *M. monophylli* æquales; bracteæ lanceolatæ acuminatæ ⅛-unciales, pedicellis æquales; sepala late lanceolata acuta; petala linearia; labellum ovatum apiculatum, basi saccata tricostata, apice acuminato acuto; columna brevis crassa, stelidiis brevibus; capsula oblonga, costis vix elevatis, ¼-uncialis.

Afghanistan, Kuram Valley, Shendtoi, *Aitchison*! N. India, Guhrwal, *Duthie*! Sikkim, Tunga, Lachen, *Hooker*! N.W. Himalaya, Hattee, *Thomson*! Gossain Than, *Wallich* no. 1935!

38. **M. cylindrostachya**, *Reichb. f. in Walp. Ann.* vi. p. 207. —Dienia cylindrostachya, *Lindl. in Wall. Cat.* no. 1934; *Orch. Pl.* p. 22.

Planta in magnitudine valde variabilis; caulis gracilis, debilis 2–7-uncialis, basi pseudobulbosa globosa, superne vagina longa ampliata truncata; folium singulum ovatum obtusum suberectum, 1½–5 uncias longum, ¾–3 uncias latum; scapus debilis sæpissime nutans, ⅓ longitudinis nudus, 3–10-uncialis; racemus longus; flores copiosis minimi aggregati; bracteæ lanceolatæ acuminatæ deflexæ, ⅛-unciales; sepala ovata acuminata acuta; petala linearia angusta; labellum ovatum acuminatum vel apiculatum, basi saccatum, marginibus incrassatis, aurantiacum?; columna basi angustata, dentes incrassatæ.

Nepal, Sheopore, Sylhet, *Wallich* no. 1934! N.W. Himalaya, *Hooker*!

§ *Crepidium.*

39. **Microstylis Godefroyi**, *Reichb. f. in Ot. Hamb.* i. p. 37.

Caulis 1½-uncialis, pseudobulbosus ovoideus, foliis undique tectus; folia 2–3, erecta lorata ligulata obtusa inæqualia, maximum 4 uncias longum, ½ unciam latum; scapus gracilis angulatus 6-uncialis (non omnino evolutus), basi longe nuda; flores minimi brunnescentes, pedicellis brevibus, bracteis lanceolatis deflexis æqualibus; sepala oblonga ovata; petala oblonga linearia; labellum angustum oblongum apice bilobum, lobis oblongis subobtusis, auriculis brevibus, fovea oblonga, marginibus incrassatis, vena mediana incrassata; columna crassiuscula, breviuscula, stelidiis longis loratis obtusis.

Cambodia, Pream Bal, *Godefroy Lebœuf*, no. 414!

40. **M. congesta**, *Reichb. f. in Walp. Ann.* vi. p. 306.—M. Bernaysii, *F. Muell. Flor. Fragm.* xi. p. 21.—Dienia congesta, *Lindl. in Wall. Cat.* no. 1936, *Orch. Pl.* p. 22; *Bot. Reg.* no. 825; *Reichb. f. in Bonplandia*, iii. p. 259.—Malaxis latifolia, *Sm., in Rees's Cycl.*—Malaxis plicata, *Roxb. Fl. Ind.* iii. p. 456.—Liparis Bernaysii, *F. Muell. l. c.*; *Bernays, Flor. Queensl.* p. 507.

Caulis crassus vaginis undique tectus, 3-uncialis; folia plura subdissita inæqualia lanceolata acuminata obliqua petiolata, 4–6-uncias longa, 1½ uncias lata; scapus validulus erectus 6–12-uncialis angulatus, basi longe nuda; racemus compactus cylindricus, 3–6-uncialis; flores parvi copiosi luteo-virides; bracteæ lineari-lanceolatæ setaceæ, inferiores, ⅛-unciales; sepala oblonga obtusa, lateralia latiora, labello subæqualia; petala linearia; labellum ovatum cymbiforme, auriculis parvis, apice trilobo, lobis lateralibus brevibus subacutis, medius longior obtusus oblongo-lanceolatus vel lineari-lanceolatus; columna crassiuscula, stelidiis parvis loratis truncatis obtusis; capsulæ erectæ ¼-unciales oblongæ pyriformes, dense aggregatæ.

India: Nepal, *Dr. Wallich*, no. 1936. Sikkim, *Hooker*! Marainhetty, *Hamilton*! Khasiya, Ladder Valley, Nunklow, *Hooker*!

Malaya: on a small island in the Straits of Rhio, *Chr. Smith.*

Siam: Angkow, *Godefroy Lebœuf*!

Hongkong, Mt. Gough, *Lamont*! *Hance*!

Australia: Trinity Bay, Queensland, *Bailey*!

A figure of "*Malaxis plicata*" by Roxburgh in the library at Kew seems intended for this plant.

The type specimen of *Microstylis Bernaysii* was very kindly sent me by Baron v. Mueller, and proves to be this common species.

Var. FUSCA.—Dienia fusca, *Lindl. Orch. Pl.* p. 22.—M. fusca, *Reichb. f. in Walp. Ann.* vi. p. 207.—M. trilobulata, *Kurz, Rep. on Vegetation of Andaman Isles, Append.* B. xix. (nomen nudum); *N. E. Brown, Gard. Chron.* Sept. 23, 1883, p. 392.

Flores purpurei, densiore congesti.

Ceylon, *Macrae*! *Thwaites*! Moulmein, *Parish*! Andaman Islands, *Col. Berkeley*!

There seems to be no real difference between this and the yellow-flowered plant, except the colour. There is an original coloured drawing of it by Macrae in the Library of the Horticultural Society.

Var. GRACILIOR.—Folia paullo angustiora, caulis longiora; scapus pedalis gracillimus, circiter dimidio nudo; racemus multiflorus tenuior; flores flavescentes, pedicellis brevissimis; bracteæ lineares setaceæ angustissimæ.

Java: Tjikoya, *Zollinger*, no. 116!

The long slender raceme gives this plant a very different appearance to that of the typical form.

41. MICROSTYLIS BIAURITA, *Lindl. in Wall. Cat.* 1941; *Orch. Pl.* p. 30.

Caulis 2-uncialis, folia 3–4 inæqualia tenuia subpatula, ovata acuta, marginibus crispis 3 uncias longa, 1½ lata (in maxima); scapus gracilis, 5–6-uncialis, majore parte racemosus; racemus 3-uncialis multiflorus laxiusculus; flores parvi lutei, pedicelli gracillimi ¼-uncialis, bracteis lanceolatis acuminatis vix breviores; sepala lanceolata subobtusa; petala angusta linearia; labellum triangulari-cordatum, auriculis longis acutis angustis, lamina triangulari-acuminatum acutum, callo ut videtur in basin; columna stelidiis majusculis rotundatis.

N. India: Zogheloree, Sylhet, *F. Da Silva in Wallich's Herb.* no. 1941!

42. Microstylis Josephiana, *Reichb. f. in Bot. Mag.* t. 6325.

Pseudobulbi oblongi fusiformes 3–4-unciales; folia 3, oblonga vel oblongo-lanceolata acuminata patentia plicata inæqualia, maxima 4–7 uncias longa, 2 uncias lata, superne olivaceo-cuprea, subtus viridia; scapus circiter 8-uncialis, sexangularis validulus, dimidio florifero; flores in genere maximi globosi, ovarii angulatis brevibus; bracteæ quam ovaria breviores ovatæ reflexæ; sepala late ovata recurva obtusa, lateralia ¾ longitudinis connata; petala late linearia recurva acuta, omnia sordide flava; labellum ventricosum gibbosum, margine superiore retuso, auriculis magnis rotundatis, imbricatis, flavum, maculis rufo-brunneis in disco præsertim circa columnam; columna brevis crassa, stelidia parva rhomboidea.

Sikkim.

43. M. Burbidgei, *Reichb. f. MS.*

Caulis vix incrassatus, foliis evolutis ferme tectus; folia petiolata vaginantia dissita valde inæqualia, inferiora lamina quam petiolus multo breviora, ovata acuta, superiora magis lanceolata acuta circa 4 uncias longa, 1½ uncias lata; scapus breviusculus, 4-uncialis vix evoluta, validulus, angulatus; bracteæ lanceolatæ setaceæ acutæ ½-unciales; flores parvi, plures; sepala ovata lanceolata acuta trinervia; petala spathulata acuta subobliqua uninervia; labellum sagittatum acutum, sepalis brevius medio depresso, auriculis magnis latis rotundatis; columna crassiuscula apice latiore, stelidiis quadratis truncatis.

Labuan, *Burbidge*! Herb. Brit. Mus.

44. M. discolor, *Lindl. Orch. Pl.* p. 20; *Bot. Mag.* t. 5403; *Wight, Icones*, t. 1631.

Caulis crassus vix bulbosus 3-uncialis, vaginis purpurascentibus tectus; folia evoluta 3–4 congesta ovata acuminata acuta tenuia crispa plicata purpurea petiolata, petiolis vaginantibus, 2 uncias longa, 1 unciam lata; scapus gracilis erectus, 4-uncialis, 1½ uncias nudus; racemus densus multiflorus, flores minimi insigniter flavi, marcescens rubri; bracteæ lanceolatæ acuminatæ deflexæ vix ¼-uncialis; sepalum posticum lanceolatum angustum obtusum, lateralia latiora obliqua elliptica obtusa; petala linearia angusta; labellum parvum ovatum cordatum integrum acutum, basi excavata, auriculæ brevis obtusæ latæ; columna brevis, crassiuscula, stelidiis lanceolatis obtusis porrectis.

Ceylon, *Macrae*! Central Province, *Thwaites*, no. 3698.

There is also an original coloured drawing by Macrae in the library of the Horticultural Society.

45. MICROSTYLIS FLAVESCENS, *Lindl. Orch. Pl.* p. 21; *Miquel, Fl. Ind. Bat.* p. 625.—Crepidium flavescens, *Blume, Bijdr.* p. 388.

Labellum integerrimum; folia subradicalia ovato-lanceolata nervosa membranacea, radix fibrosa; flores spicati flavescentes.

Java.

This description is obviously too incomplete to distinguish the species. However, I have not yet seen any plant from Java with yellow flowers and an entire lip. Some plants labelled *M. flavescens* var. *purpurea* by Dr. Reichenbach in herb. Kew I cannot distinguish from *M. congesta* var. *fusca*. I do not think Blume can have intended *M. congesta* by his *Crepidium flavescens*, as the lip of the former is certainly not "*integerrimum*." Lindley says, "An eadem ac *Microst. discolor*?"

46. M. BILOBA, *Lindl. Orch. Pl.* p. 20; *Wall. Cat.* no. 1940.

Caulis crassus, vaginis paucis tectus; folia 4 ovata lanceolata valde inæqualia acuta plicata, 6 uncias longa, 2 lata; scapus validulus angulatus pedalis ferme omnino racemosus; bracteæ anguste lineares acuminatæ deflexæ, 4 lineas longæ; flores iis *M. Wallichii* æquales, pedicellis 3 lineas longæ, suberectis; sepala lata oblonga ovata obtusa, lateralia obliqua, petala linearia; labellum ovatum sagittatum, auriculis magnis lanceolatis obtusis curvis, lamina apice bifido, lobis lanceolatis obtusis, fovea parva oblonga quadrata, margine antica incrassata; columna crassiuscula; clinandrium latum, stelidia lata truncata.

Nepal, *Wallich*, no. 1940!

47. M. WALLICHII, *Lindl. in Wall. Cat.* no. 1938; *Orch. Pl.* p. 20.

Caulis basi incrassata circiter 2-uncialis, pseudobulbo vetusto sæpius approximato conico unciali; folia sæpe 3–4 viridia vel discoloria inæqualia ovata lanceolata acuminata acuta, suberecta, vaginis longis 5 uncias longa, 1½ uncias lata; scapus 3–10-uncialis, basi circiter ⅓ tereti nuda, superne angulatus nonnunquam nutans; racemus valde laxus pauciflorus; bracteæ $\frac{3}{16}$ unciam longæ lanceolatæ acuminatæ, mox deflexæ; flores parvi virides pallide purpurascentes, præsertim marcescentes; sepala oblonga linearia obtusa, marginibus revolutis; petala linearia, sepalis minora; labellum sagittatum ovatum, apice bifido, lobis acutis, auriculis magnis excurvis subacutis, fovea vix profunda, linea mediana elevata; columna brevis, stelidiis læte viridibus loratis obtusis.

Nepaul: Chondagherry, *Wallich*, no. 1938 I. Silhet, *Da Silva*, 1938 II. Khasiya, *Lobb*! Nunklow, *Hooker*, no. 1653!

Guhrwal, *Hooker & Thomson*! Moulmein, *Parish*. Anamallay Hills, *Col. Beddome*! Cambodia, Mt. Pursat, *Lebœuf*, p. 442!

V. v. in hort. Kew, 1886, 1887.

Var. OMPHALOIDES, *Parish*.—Labellum rotundatum obtusum.

Moulmein, *Parish*!

This apparently common plant varies very much in the shape of the lip, which is typically ovate with a bifid apex; but the amount of fission varies greatly. The auricles too sometimes overlap behind the column and sometimes do not touch each other. In the variety *omphaloides* the lip is so rounded that, as the auricles meet behind, the column appears to emerge from the centre of a circular lip. In colour the flowers vary from "chestnut-red" (*Hooker*) to green, tinted, especially at the base of sepals, petals, and lip, with purplish.

48. MICROSTYLIS CARINATA, *Reichb. f. in Walp. Ann.* vi. p. 618. —Dienia carinata, *Reichb. f. in Bonplandia*, iii. p. 223.

Caulis crassus, vaginis tectus; folia 5, lanceolata obliqua acuta valde inæqualia dissimilia petiolata, inferiora ovata lanceolata subdissita, lamina 5 uncias longa, 1 unciam lata, petiolus vaginatus 1½ uncias longa; scapus 8-uncialis, validulus, basi (4 uncias) nuda; flores pauci parvi flavi; bracteæ lanceolatæ acuminatæ deflexæ, ¼ unciam longæ, superiores minores; sepalum posticum oblongum loratum obtusum, lateralia latiora elliptica obtusa quam labellum breviora; petala sepalo postico similia vel linearia (fide Reichenb. fil.); labellum ovatum cordatum abrupte acuminatum, subtrilobum, lobis lateralibus vix distinctis rotundatis, medio acute acuminato, fovea vix distincta, lineis elevatis duabus, callis nullis, auriculis majusculis rotundatis obtusis; columna brevis, stelidiis latis lineari-loratis apicibus rotundatis.

Philippine Islands, *Cuming*, no. 2144! Luzon, *Lobb*!

49. M. OCULATA, *Reichb. f. in Flora*, 1886, p. 554.—Anectochilus javanicus, *Hort.*

Folia 7–8 congesta ovata petiolata undulata plicata subæqualia, 3 uncias longa, 1¼ uncias lata, disco laminæ olivaceo-viridi vel brunnescente marginibus albis; scapus 6-uncialis angulatus longe (4 uncias) laxe racemosus; flores parvi dissiti circiter 50, pallide smaragdini, pedicellis tenuibus ¼-uncialibus; bractæ lineari-lanceolatæ deflexæ, pedicellis æquales; sepala lanceolata lorata obtusa, marginibus revolutis, lateralia paullo obliqua; petala anguste linearia; labellum cordatum, apice obscure trilobum, lobi

laterales breves rotundati, medius longus integer subacutus, auriculæ longæ recurvæ, fovea depressa, callus basalis in venis duabus ad basin attenuatus; stelidia dentiformis acuta.

Java; cult. in hort. Peradeniya, comm. *Dr. Trimen*!

I suppose this to be the plant intended by Prof. Reichenbach, though he says that in his plant the flowers were "flavi auriculis purpureis et labellum apice bidentato utrinque paucidentato."

50. MICROSTYLIS POLYPHYLLA, n. sp.

Caules 2 approximati, haud pseudobulbosi, omnino foliati, biunciales; folia alterna subæqualia, inferioribus autem minoribus, 4–8, lanceolata acuta subplicata, petiolata, petiolis vaginantibus laxis, lamina 3 uncias longa, ¾ unciam lata; scapus 9-uncialis erectus subteres superne angulatus, basi 5-unciali nuda, bracteis paucis exceptis; racemus densus multiflorus; flores parvi flaviduli; bracteæ lanceolatæ acuminatæ setaceæ deflexæ, pedicellis tenuibus subæquales; sepala lanceolata obtusa, lateralia obliqua; petala lanceolata angustiora; labellum lateralibus subæquale, late cordatum hastatum, apice obtuse trilobo, lobis lateralibus brevibus rotundatis obtusis, medio longiore elliptica obtuso; auriculæ latæ obtusæ; callus ad basin hippocrepiformis, in venis duobus attenuatus, in fovea longiuscula; stelidia brevia lata truncato-rotundata.

New Caledonia, *Vieillard*, no. 374! Herb. Brit. Mus.

51. M. TAURINA, *Reichb. f. in Linnæa*, xli. p. 97.

Caulis vix incrassatus, 6-uncialis, undique laxe foliatus; folia 8–10 dissita lanceolata acuta aliquando acuminata, obliqua tenuia petiolata, petiolis longis vaginantibus, lamina 3 uncias longa, ¾ unciam lata; scapus elatus 9–12-uncialis angulatus, basi longe nuda, bracteis paucis exceptis; racemus multiflorus; flores dissiti sulphurei vel purpurascentes, parvi; bracteæ lanceolatæ acuminatæ reflexæ circiter ¼-uncialis; sepalum posticum et petala subsimilia, lanceolata lorata obtusa subæqualia; sepala lateralia ovata multo latiora obtusa; labellum magnum, sepalis lateralibus æquale, trilobum, lobi laterales lati rotundati, apices acuminati lineares, lobus medius longior lanceolata, apice breviter bifido; auriculis magnis rotundatis, in media laminæ ad basin, depressione elongata obscuriore; calli nulli; columna longiuscula arcuata, stelidiis loratis obtusis elongatis.

New Caledonia, "Bord de Cangui," *Vieillard*, no. 3274, no. 3276!

52. Microstylis purpurea, *Lindl. Orch. Pl.* p. 20.

Caulis erectus conico-incrassatus circiter 3-uncialis, vaginis tectus; folia 5–6 in apicem caulis subcongesta valde inæqualia ovata lanceolata acuminata obliqua subpetiolata, petiolis vaginantibus, maximum 6 uncias longum, 1¾ uncias latum; scapus 6-uncialis, apice nutante basi nuda; racemus laxiusculus ad 40-florus; bracteæ lanceolatæ setaceæ deflexæ ¼-unciales; pedicelli tenues vix longiores; flores majusculi purpurei; sepalum posticum lanceolatum lineare, lateralia falcata; petala linearia angusta; labellum magnum cordatum auriculis magnis obtusis, apice subtrilobo, lobus medius bifidus, laterales rotundati, fovea triangularis margine elevata; stelidiis brevibus obtusis.

Ceylon, *Macrae*!; *Thwaites*, no. 3768.

Java, *Zollinger*, no. 2536!

The plant obtained by Dr. Seemann in Fiji and distributed under no. 613 is referred here by Dr. Reichenbach. All the specimens I have seen under this number in the Kew and British Museum herbaria belong to quite a distinct species, but are not sufficiently good to describe from.

53. M. calophylla, *Reichb. f. in Gard. Chron.* n. s. xii. 1879, p. 718.—Liparis elegantissima, *Hort.*

Caulis conicus brevis pseudobulbosus; folia plura, congesta, ovata vel oblonga lanceolata acuta, marginibus paullo undulatis 5 uncias longa 2 uncias lata olivaceo-brunnea, margine late viridi transversim brunneo-striata; scapus gracilis nutans circiter 6-uncialis, ferme omnino laxe racemosus; flores parvi pulchre smaragdini, marcescentes flavi, remoti circiter 16, pedicellis tenuibus cum ovariis ¼-uncialibus; bracteæ lineari-lanceolatæ setaceæ ⅛-unciales; sepala oblonga obtusa, lateralia obliqua, marginibus revolutis, purpurascentia; petala angusta linearia purpurascentia; labellum smaragdinum sagittatum parce albo-ciliatum, auriculis magnis lanceolatis curvis subacutis, lamina lata subtriangulari triloba, lobi laterales breves rotundati, medius paullo longior, apice bifido, laciniis forcipatis parvis; callus ad basin hemisphæricus, venis elevatis duabus albis, foveam percurrentibus, ad pulvinam terminatis, macula purpurea in utro latere ad basin; columna basi angustata, stelidiis magnis rotundatis spathulatis smaragdinis.

Malaya, *loc. spec. ignotus.* Mr. F. Moore kindly sent me this plant from Glasnevin Gardens.

54. Microstylis chlorophrys, *Reichb. f. in Gard. Chron.* n. s. xv. 1881, p. 206.

Folia oblonga acuta, pagina superiore brunnea, inferiore purpurascente, margine valde undulata; racemus pauciflorus; bracteæ roseæ triangulæ uninerviæ, ovariis multo breviores; sepala triangula; petala linearia acuta, omnia purpurea; labellum sagittatum trifidum, laciniis lateralibus abbreviatis dentibus antrorsis, lacinia mediana triangula bidentata longe producta, lamella transversa oblonga medio apiculata in basi.

Borneo, *introd. Bull.*

55. M. segaarensis, *Kränzlin, in Engl. Bot. Jahrb.* vii. p. 435.

Caules foliosi. Folia patula erecto-recurva angusta lanceolata acuminata acuta, 6 vel plures, maximum 9 uncias longum; $\frac{3}{4}$ unciam latum; scapus subdebilis alatus 9-uncialis 30-florus; bracteæ lanceolatæ acutæ deflexæ; sepala ovata obtusa; petala latiora rotundata breviora; labellum trilobum, lobi laterales maximi semiorbiculares, intermedio profunde bilobo, antice grosse dentato, basi excavata, stelidia in brachiis protracta.

New Guinea, MacCluer Bay, *Dr. Naumann*!

Dr. Kranzlin very kindly sent me the unique specimen of this rare plant to examine. The flowers seem to have been orange-coloured. Its habit is much that of *M. polyphylla* and *taurina*.

56. M. Ventilabrum, *Reichb. f. in Gard. Chron.* n. s. xvi. 1881, p. 717.

Folia oblonga acuta, pallide viridia brunneo nervosa, plicata; scapus minute angulatus; racemus pluriflorus anthesi distantiflores; bracteæ triangulæ acutæ, ovario pedicellato ter breviore; flores parvi pulchre flavi; sepalum posticum ligulatum acutum, lateralia cuneato-oblonga acuta; labellum aurantiacum transversum, basi lata abrupta utrinque margine externo semisagittato utroque latere retuso, antice septemdentato, dente mediano producto, dentibus externis bidenticulatis; columna alba utrinque viridis.

Sonda Isles. Only known in cultivation.

57. M. metallica, *Reichb. f. in Gard. Chron.* n. s. xii. 1879, p. 750; *Bot. Mag.* t. 6668.

Herba subpedalis, caulis pseudobulbosus cylindricus crassus, purpureus, uncialis, vaginis albescentibus tectus; folia 6 vel pauciora, lanceolata ovata vel oblonga acuta, breviter petiolata subpatula, marginibus crispis, 2 uncias longa 1 unciam lata, atropurpurea nitida, subtus pallidiora; scapus gracilis violaceus 6–7-uncialis; racemus valde laxus circiter multiflorus; bracteæ purpurascentes lanceolatæ acutæ deflexæ; flores parvi pedicellis gracilibus ½–¾ unciam longis, patentibus vel recurvis; sepalum posticum lineari-ligulatum, roseum vel flavum, lateralia vix latiora oblonga ligulata, rosea vel flavescente-rosei; petala linearia angustiore rosea; labellum roseum cordatum obcuneatum quadratum, apice rotundato parce dentato, dentibus brevissimis; auriculæ majusculæ lanceolatæ acutæ; calli duo ad basin columnæ; columna brevis crassiuscula flava, apice viridi; stelidiis dentiformibus acutis; anthera oblonga lata apice retuso.

Borneo, *v. c.*

58. MICROSTYLIS PLATYCHEILA, *Reichb. f. in Seem. Flor. Vit.* p. 302.

Cauli basi bulbosa, bulbo tereti conico; foliis petiolatis oblongis acutis; inflorescentia longissima racemosa; bracteæ pedicellis subæquantibus linearibus acutis deflexis; ovariis 6-gonis, sepalis oblongis plurinerviis, basi connatis, petalis cuneato-ovatis obtusis uninerviis, labello transverso utrinque obtuso, lobo antico minute prosiliente, carinis 4 in disco elevatis; columna minuta bicorni.

The whole plant has a purplish hue.

Fiji Islands, Somosomo, island of Taviuma and Kadavu, *Seemann*, no. 590.

I know no more of this plant. The specimens distributed under this number by Dr. Seemann appear to be *M. Rheedii* in a bad state; the laminæ of all the lips in the specimens which I have examined in the herbarium of the British Museum being bitten off, probably by a snail. The plant under the same number at Kew again may be different. The scape is very long and slender, and bore many flowers; unfortunately in one specimen all are gone save a very young bud or two, and the second specimen is in fruit.

59. M. RHEEDII, *Lindl. Orch. Pl.* p. 21.—Epidendrum resupinatum, *Forst. f. Prodr.* n. 322.—Pterochilus plantagineus, *Hook. & Arn. Bot. Beechey's Voyage*, p. 71, t. 17.—M. bella, *Reichb. f. in Gard. Chron.* 1886, Jan. 2, p. 8.—M. plantaginea, *Cuzent, Tahiti*, p. 239.

Caulis cylindricus vel conico-cylindricus, 3-uncialis; foliis vaginantibus tectus; folia 4–5, dissita, oblongo-lanceolata acuminata obliqua subæqualia, patula, basi angustata, viridia nec lucida, 5-nervia, 5–6 uncias longa, 2–3 uncias lata; scapus erectus angulatus pedalis vel ultra, purpureus, basi longe nuda, bracteis paucis exceptis; racemus multiflorus laxus; flores mediocres, pulchri, pedicellis brevibus crassiusculis; bracteæ lanceolatæ acutæ angustæ erectæ demum deflexæ, ⅛ unciam longæ, purpurascentes; sepala lorata ligulata obtusa, purpurea vel viridi-purpurea, marginibus revolutis; petala subsimilia angustiora; labellum magnum kermesino-purpureum, ⅜ unciam longum, quadratum sagittatum, auriculis magnis acutis, apice acute dentato, dentibus subæqualibus 8–9, fovea profunda margine anteriore incrassato, subcarnoso atro-purpureo; columna basi angustata superne dilatata, stelidiis quadratis truncatis læte viridibus, lobus hemisphæricus, planus, purpureus, ad basin columnæ; pollinia pyriformia cura; capsulæ erectæ, elongatæ, pyriformes, ½ unciam longæ.

Sunda Islands, intr., *Linden, v. v. Hort. Kew.*

Society Islands, Otaheite, *Barclay*, 3302! *Banks*! *Forster*! Erocomio, Otaheite, *Wiles & Smith.*

60. **Microstylis bancana**, n. sp.—Crepidium Rheedii, *Blume, Bijdr.* i. p. 387, fig. 63?

Habitus *M. Rheedii*; caulis longus nunquam bulbosus, ascendens, foliis dissitis tectus; folia circiter 8, dissita inæqualia lanceolata obliqua acuminata petiolata, lamina 6 uncias longa, 1½ lata; petiolus 1½ uncias longus, basi vaginata ampliata; scapus longus, debilis ferme bipedalis; flores parvi plures, dissiti flavescentes?; bracteæ breves lanceolatæ deflexæ; sepala late lanceolata oblonga obtusa, lateralia haud falcata, labello breviora; petala late linearia; labellum triangulare, auriculis lanceatis subobtusis, lamina apice 4–5-dentato, dentibus majusculis, fovea vix profunda marginibus crassis, callus integer; columna breviuscula basi angustata.

Banca, *Horsfield*! Herb. Brit. Mus.

A specimen of *Crepidium Rheedii*, Blume, named in Blume's handwriting, exists in the British Museum. Unfortunately it is only in fruit. It is much like the Banca plant, but the stem is shorter and leaves more crowded, and the scape is no longer than the leaves.

61. **M. versicolor**, *Lindl. Orch. Pl.* p. 21; *Wall. Cat.* no. 1939.—Malaxis Rheedii, *Swartz*; Basaala-poulou-maravara, *Rheede, Hort. Malab.* xii. t. 27.—Liparis priochilus, *Loddiges, Bot. Cab.* t. 1751.—Liparis intermedia, *Rich. Orch. Nilgh.* p. 13?

Caulis gracilis, 3½–4-uncialis, vaginis pluribus purpurascentibus tectus, haud incrassatus; folia congesta ad apicem, 3–4 inæqualia elliptica lanceolata vel ovata acuminata acuta 5-nervia, tenuia, plicata viridia, breviter petiolata, petiolus uncialis vaginatus, vagina ampliata, lamina 2½–6 uncias longa, 1–2 uncias lata; scapus elongatus gracilis, rarius validulus, 8–10-uncialis, ferme omnino racemosus angulatus; flores copiosi parvi, flavi, morientes rubri; bracteæ lanceolatæ longe acuminatæ deflexæ, ¼-unciales; sepala et petala omnia deflexa lanceolata lorata obtusa, petala angustiora obliqua, lateralia latiora obliqua, petalis breviora; labellum breve, parvum haud bilobum, latum, basi unguiculatum, columna subparallela, callo plano triangulari, apice bilobo parvo ad basin, lamina deflexa inferne depressa, margine dentato, dentibus circiter 10 subæqualibus brevibus obtusis; columna longuiscula paullo arcuata basi angustata, stelidiis dentiformibus.

S. India, Anamallays, *Beddome*! *Herb. Heyne*, *Dr. Wallich*, 1939.

Ceylon, *Macrae*! Hautane, *Gardner*, no. 844! Central Province, *Thwaites*, no. 2375! 2743.

Thwaites's specimens differ from those of the other collectors in having the pedicel considerably longer and the flowers a little larger. The column too seems somewhat stouter, and the lateral sepals broader and blunter. There is a good original drawing of the plant in a book of Cingalese drawings by Macrae in Bibl. Hort. Soc.

62. **MICROSTYLIS PRATENSIS**, n. sp.—M. versicolor, *Wight, Icones*, t. 901; *non Lindl.*—Liparis densiflora, *A. Rich. in Ann. Sc. Nat.* sér. 2, xv. 1841, p. 18, pl. 1 B.

Planta variabilis, caule pseudobulboso conico, 3-unciali, vaginis foliaceis rarius membranaceis 1–2 tecto; folia lanceolata acuta vel ovata lanceolata acuminata, inæqualia, 2–5 erecta vel paullo recurva, nec patula, nec petiolata, 5-nervia, 1–3 raro 4 uncias longa, ½–1 unciam lata; scapus 3–6-uncialis fere omnino racemosus; flores copiosi parvi purpurei; bracteæ ovatæ lanceolatæ vel lanceolatæ acuminatæ deflexæ, ⅛-unciales; pedicelli breves; sepala lanceolata angusta obtusa, lateralia quam postica paullo latiora paullisper obliqua; petala linearia obtusa, sepalis paullo angustiora; labellum unguiculatum cuneatum, apice bilobum, margine laciniato, laciniis angustis subinæqualibus acutis longiusculis, circiter 12; fovea triangularis, haud profunda marginibus incrassatis, callo conico obtuso parvo ad basin; columna graciliuscula arcuata, stelidiis dentiformibus subobtusis.

S. India, Pulney Mts., Nilgherries, *Wight! Gamble*, 1733. Wadearhatti, *Meetz, Pl. Ind. Or.* no. 1321! subnom. *Liparis densiflora.* Anamallay Mountains, *Beddome*! Ootacamund, *Beddome*!

This little plant, apparently common in grassy pastures on the Nilgherrie hills, in India, has been much confused with *M. versicolor*. It varies much in length of raceme and stem, but its lanceolate sessile leaves and swollen pseudobulb at once distinguish it.

The three species *M. Rheedii, pratensis*, and *versicolor* are somewhat closely allied, and have been much confused. *M. Rheedii* is at once distinguished by its much larger flowers and more oblique leaves, and is, I believe, confined to the Fiji Islands, whence I have not seen either of the other two. *M. versicolor* has a straight narrow stem not at all swollen at the base, at the top of which the leaves are arranged in a tuft. *M. pratensis* has a short pseudobulbous stem, distinctly swollen at the base, from which the erect or at least not spreading nor petiolate leaves arise. Sometimes, certainly, the stem is a little elongate, but it always seems to retain its swollen base. The flowers are as large as those of *M. versicolor*, but the lateral sepals are neither so curved nor so broad as they are in that species, but more resemble the dorsal one. The lip too is longer and more deeply laciniate, and bilobed as well. I have only seen it from the mountains of Southern India.

63. MICROSTYLIS LUTEOLA, *Wight, Icones*, no. 1632.

Pseudobulbus parvus, ovoideus; caulis gracilis brevis, folio vaginante lanceolato, tectus; folia evoluta sæpius 2, dissita lanceolata acuta, 2 uncias longa, ½ unciam lata; scapus suberectus vel nutans, ultra dimidio racemosus, circiter 4-uncialis; flores parvi et pauci flavi; bracteæ quam pedicelli vix breviores lanceolatæ setaceæ deflexæ; pedicelli ⅛-unciales curvi; sepalum posticum lanceolatum loratum obtusum, lateralia lanceolata obtusa obliqua latiora; petala angusta linearia; labellum late triangulari-cordatum, apice latum, dentibus vel potius laciniis acutis pluribus, basi parum depressa, callo parvo ad basin columnæ; columna basi angustata, dentibus duobus acutis minutis ad apicem.

India, Malabar, Concan, &c., *Stocks & Laws*!

Ceylon, *Thwaites*, no. 2743!

64. **Microstylis crenulata**, n. sp.

Caulis brevis circiter uncialis, vix pseudobulbosus, vaginis foliaceis duobus tectus; radices lanati; folia 1 rarius 2, dissita lanceolata acuta trinervia valde inæqualia breviter petiolata, petiolo vaginante lamina 1½ uncias longa, ¾ lata; scapus gracilis 4-uncialis, apice nutante, majore parte laxe racemosa; bracteæ lanceatæ acuminatæ deflexæ $\frac{1}{12}$ unciam longæ, infimæ multo longiores ad ¼ unciam lanceolatæ foliaceæ; flores parvi visi virescentes, pedicellis duplo bracteis longioribus; sepalum posticum oblongum lanceolatum, lateralia ovata obtusa falcata, petala lanceolata a basi latiore attenuata marginibus revolutis; labellum reniforme rotundatum crenulatum, basi breviter unguiculata, fovea vix depressa; callus conicus obtusus, auriculis nullis; columna quam ea *M. versicoloris* brevior crassiorque.

S. India, West Nilgherries, *Col. Beddome*! in herb. Brit. Mus.

65. M. **lancifolia**, *Thwaites, Enum. Pl. Zeyl.* p. 297.

Caules pseudobulbosi conici seriatim approximati ¼ unciam longi, basibus foliorum tecti; folia circiter 5–6 erecta subcongesta subæqualia lanceolata obliqua acuta petiolata, 2–3 uncias longa, ¼ unciam lata; scapus gracilis 6-uncialis ferme omnino racemosus, circiter 1½ uncias nudus; flores plures dissiti parvi flavidi, pedicellis tenuibus, bracteis vix longioribus; bracteæ lanceolatæ acutæ $\frac{3}{16}$-unciales; sepala lanceolata lorata obtusa, lateralia labello æqualia obliqua; petala linearia obtusa; labellum obtriangulare, apice lato recto, laciniis circiter 6 brevibus obtusis, basi parum depressa, callo hemisphærico ad basin; columna altiuscula basi angustata, dentibus duobus minutis acutis; capsula oblonga, 3 lineas longa.

Ceylon, Suffragan District, *Thwaites*, no. 2742! Karanitie Kandie, *Trimen*!

66. M. **cardiophylla**, *Reichb. f. in Flora*, 1885, p. 543.

Planta debilis; caulis gracilis, tenuis, haud incrassatus, 2-uncialis, vaginis remotis 2–3, laxis albescentibus membranaceis inæqualibus; folia dissita 2–3, tenuia ovata subacuta trinervia, unciam longa, ¾ unciam lata, petiolis vaginantibus ½ unciam longis; scapus 4-uncialis gracillimus nutans tetragonus ferme omnino laxe racemosus, purpureus; bracteæ lanceolatæ subulatæ uninerviæ amplexicaules, superiores magis ovatæ breviores circiter ⅛-unciales, purpurascentes; pedicelli tenuissimi patuli $\frac{3}{16}$-unciales, purpurei; flores pauci minimi; sepala ovata acuta; petala linearia obtusa angusta; labellum sepalis brevius, cordatum oblongum obtusissimum, apice lato obscure sinuato, venis medianis tribus paullo elevatis, auriculis subnullis; columna semiteres; stelidiis brevibus obtusis truncatis; anthera ovata.

Comoro Islands, *Humblot*, no. 437!

67. **Microstylis stelidostachya**, *Reichb. f. Otia Hamburg*, ii. 118.

Caules gracillimi teretes, vaginis paucis pallidis membranaceis laxis tecti, radicibus longis tenuibus; folia 2–3 ovata acuminata subæqualia, subopposita, 5-nervia, 2½ uncias longa, 1½ uncias lata; scapus gracilis erectus vel nutans teres, 6-uncialis, basi longe nuda; racemus primo densiusculus; flores parvi plures atro-purpurei, iis *Stelidis* cujusdam simulantes, pedicellis brevibus; bracteæ ovatæ lanceolatæ acuminatæ amplexicaules virides, haud deflexæ vix ⅛-unciales, pedicellis æquales; sepala oblonga lanceolata obtusa; petala linearia; labellum oblongum cuneatum bilobum, carinis duabus cristatis flavis versus basin.

W. Africa, Prince's Island, *Mann*, 1151!

68. **M. commelynæfolia**, *Zollinger, Naturgenesk Arch.* 1844, p. 402; *Bot. Zeit.* 1847, p. 456; *Reichb. f. in Bonplandia*, 1857, p. 58; *Walp. Ann.* i. p. 744; *Miquel, Fl. Ind. Bat.* iii. p. 389.

Planta cæspitosa decumbens habitu cujusdum Commelinacea. Caules undique foliati prostrati, sex unciales vel ultra; folia dissita, alterna, patentia ovata crispa viridia, ⅝ unciam longa ¼ unciam lata, vaginæ ¼ unciam longæ, purpurascentes; scapi graciles purpurei angulati erecti ferme omnino racemosi triunciales; racemus laxus; flores minimi, viridescens; pedicellis brevibus arcuatis purpureis; bracteæ lineares setaceæ ⅔ pedicelli æquales, ⅛ unciam longæ; sepala lorata elliptica obtusa, lateralum apices purpurei; petala recurva patula angustiora linearia breviora; labellum ovatum hastatum minute crenulatum, auriculis magnis lanceatis acutis, fovea majuscula, marginibus incrassatis, purpureis; columna breviuscula, stelidiis loratis obtusis.

Java; *v. v. in Hort. Kew.*; *Lobb* 191! *Zollinger*, no. 1748!

Malaxis,

Swartz, in Stockh. Nya Handl. 1800, p. 233, t. 3; *Lindl. Gen. & Sp. Orch. Pl.* p. 23; *Lestiboudois, Bull. Soc. Roy. Bot. Belg.* vi. 1866, p. 81; *Benth. & Hook. f. Gen. Plant.* iii. p. 494.

On the vegetative organs, *Hornschuch, in Flora*, 1838, p. 257, t. 2.

On the production of buds on the leaves, *Dickie, in Journ. Linn. Soc. Bot.* xiv. p. 1.

On fertilization, *Darwin, Fertiliz. Orch.* p. 130.

This monotypic genus is closely allied to the preceding, and especially to the section *Dienia*, which it resembles in the size and form of its flowers. The rhizome is ascending, slender, and rootless. The minute pseudobulb is globose, produced at the summit of the rhizome; in the second year the rhizome is continued laterally to the pseudobulb, and thus parallel to the scape; it grows to a length of 1–2 inches before producing the next pseudobulb. The leaves are generally three, unequal, oval or lanceolate, thin and blunt, and not rarely produce bulbils on their margins. The scape is erect and racemose. The flowers resemble those of *Microstylis*, but the lip has no true fovea. The stelidia are very short and blunt, while the anther does not fall off, or even become partially detached, but shrinks downwards leaving the pollinia bare.

MALAXIS PALUDOSA, *Swartz, in Stockh. Nya Handl.* 1789, p. 127, t. 6. f. 2; *Fl. Ind. Occ.* p. 1443; *Smith, Engl. Bot.* t. 72; *Willd. Sp. Pl.* iv. p. 91; *Flora Danica*, t. 1233; *Reichb. f. Ic. Fl. Germ.* vol. xiii. p. 165, t. 4095; *Curtis, Flor. Lond.* v. p. 197; *Baxter, Brit. Bot.* v. p. 394; *Rœmer, Fl. Eur.* iii. p. 4; *Lindl. Gen. & Sp. Orch. Pl.* p. 23; *Bauer, Ill. Gen. Orch.* t. 1; *T. Nees, Fl. Germ., Monoc.* iii. n. 14.—Ophrys paludosa, *Linn. Sp. Pl.* 1341; *Richter, Codex*, 6849.—Epipactis paludosa, *F. W. Schmidt, in Mey. Phys. Aufsatz*, 1791, p. 245.

Planta pusilla, 2–8 uncias alta; rhizoma ascendens tenue; pseudobulbus ¼-uncialis conicus; folia evoluta bina membranacea erecta lanceolata vel ovato-lanceolata, ¾–1 unciam longa, ¼ rarius ½ unciam lata; scapus 1–6-uncialis, gracilis angulatus, basi longe nuda, apice laxe racemoso, 7–35-floro; flores minuti virides resupinati, pedicellis brevibus; bracteæ lanceolatæ acuminatæ, pedicellis æqualibus; sepala ovata obtusa apicibus cucullatis, posticum paullisper majus, ovario cum pedicello æquali; petala lanceolata acuta abrupte recurva, sepalis minora; labellum erectum lanceolatum cymbiforme obtusum, herbaceo-viride, lineis 4 obscurioribus in medio; columna brevissima crassiuscula, viridis; clinandrium erectum, rostellum obtusum; anthera albescens, loculi 2 distincti in locellis 4 divisi; pollinia 4 oblonga pyriformia per paria connata, ovarium pyriforme valvis placentiferis quam steriles bis latioribus; capsula parva erecta oblongo-globosa, pyriformis, costis vix prominulis.

Central and West Europe:—Ireland: Antrim, Clare, Wicklow, Dublin, Kerry. Wales, rare. England and Scotland, almost all parts. Scandinavia: Stockholm (*Nyman*!); Langmoosen, Upland (*Ahlberg*!); Upsala (*Fries*)! Russia: Wilna (*Gorski*); by Lake Serhenskoje, Ingria (*Meinetshausen*)!; Antzen, Livonia (*Lehmann*)! Denmark: Schleswig (*Tessen*!); Horreby, Lyngbei Falster (*Lange*); Schleswig Holstein (*Hansen*)! Belgium: Louette, Saint Pierre, Namur (*Crépin*)! Holland, Utrecht and Brabant (*Bosch*)! Germany: Bitche, Moselle (*Schultz, Herb. Norm.* no. 148)! (*Billot, Fl. Exsic.* no. 78)!; Greifswalde (*Walpers*! *in Reichb. Fl. Exsic.* no. 2015); Berlin (*Garcke*)!; Sommerfeld, Frankfurt (*Baenitz*)!; Hapsal (*Jürgens*)!; Eppendorf, Hamburg (*Sonder*)!; Siegburg (*Wolde*)!; Tilgte, Münster (*Wilms*)!; Wolgast, Pomerania (*Zaber*)! Austria, Kitzbuhel (*Traunsteiner*)!

Species dubiæ.

Malaxis brasiliensis, *Spreng. Syst.* iii. p. 740.
M. thlaspiformis, *Rich. & Gal. Orchid Mex.* p. 18.
M. monticola, *Rich. & Gal. Orchid. Mex.* p. 18.

Species excludendæ.

Microstylis atropurpurea, *Miq. Fl. Ind. Bat.* iii. p. 625 = Liparis.
M. decurrens, *Miq. l. c.* = Liparis decurrens.
Malaxis nutans, *Willd.* = Geodorum, sp.
M. oblongifolia, *Rich. & Gal. Orch. Mex.* p. 18.

APPENDIX.

The following additional notes on my monograph of the genus *Liparis* are based upon material which has since come before me.

L. chloroxantha, Hance! is *L. plicata*, Franchet!

L. elegans, Lindl. Orch. Pl. p. 30.—Mr. Rolfe showed me at Kew a living flower-spike of what he considered to be the plant intended by Lindley for this species. I have little doubt that he is correct in his surmise. The plant is quite distinct from any described in my paper, unless *L. Stricklandiniana*, Reichb. f., which I have not seen, be a synonym. There are also specimens in fruit collected by Maingay in Malaya, both in the herbaria of the British Museum and Kew, which I had been hitherto unable to refer to any species. I append an emended description.

Liparis elegans, *Lindl. in Wall. Cat.* no. 1943, in part; *Gen. & Sp. Orch. Pl.* p. 30; *Rolfe, in Gard. Chron.* n. s. xxvi. 1886, p. 558.

Rhizoma ascendens diu repens, lignosum, pseudobulbi dissiti, clavati, 1½-unciales, vaginis viridibus lanceolatis acutis laxis in sicca tecti; folia elliptica lanceolata subobtusa basi angustata, 6 uncias longa, ¾ unciam lata; scapus erectus validulus 9-uncialis; flores pro sectione majores, copiosi; bracteæ lanceolatæ acutæ, ovariis æquales; sepalum posticum oblongum, lateralia obliqua latiora obtusa; petala linearia omnia pallide viridia; labellum aurantiacum oblongum bilobum, lobis brevibus rotundatis obtusis minute ciliatis, ad basin unguis callis duobus parvis cornutis; columna gracilis arcuata viridis, stelidiis rotundatis; capsula erecta oblonga.

Penang, *Gen. Porter*!, *Herb. Wall.* no. 1943 *ex parte*, *Curtis*, *v. v. in hort. Kew*; *Maingay*, no. 1599.

L. venosa, n. sp.

Caulis crassus vix bulbosus, pseudobulbo vetusto conico approximato, vaginis tectus 2–3-uncialis; folia plura 3–4 congesta, inæqualia, circiter 4 uncias longa, 1½–2 uncias lata, ovata lanceolata plicata acuta, purpurascenti-viridia; scapus validus 9 uncias altus angulatus et alatus ferme omnino floriferus purpureo-kermesinus; flores plures circiter 20 dissiti inter *Mollifoliis* maximi speciosi; bracteæ parvæ lanceatæ acutæ recurvæ ⅛-unciales; pedicelli graciles patentes 1¼ uncias kermesini; sepala lorata convoluta viridia, lateralia labello supposita latiora; petala angustissima filiformia kermesina, sepalis breviora; labellum magnum, unciam longum, ¾ unciam latum (quo latissimum) ovatum obtusum unguiculo brevissimo, translucens pulcherrime kermesino-venosum, basi excavata, marginibus incrassatis, callus pulvinatus albus; columna subarcuata apice clavata, alis brevibus latis, alba, ventre ad basin excavato, marginibus kermesinis.

India, *v. v.* I received this from the Glasnevin Gardens without locality, but find a drawing of it at Kew by Miss Little, who found it at Johore. It is a most beautiful plant, and is allied to *L. nepalensis*.

L. Trimenii, n. sp.

Planta pusilla, 3–4-uncialis, pseudobulbo minimo; folia bina inæqualia lanceolata acuta vel ovata lanceolata obtusa, ½ unciam

longa vix ¼ unciam lata; scapus 2½-uncialis subflexuosus teres; bracteæ lanceolatæ acuminatæ, superiores 4 mm. longæ; flores ad 13, parvæ virescentes tenues; sepalum posticum lineari-oblongum obtusum, lateralia subsimilia obliqua; petala linearia labellum oblongum subspathulatum, apice rotundatum, marginibus minute dentatis, callis cariniformibus duobus brevibus ad basin; columna cycnicollis gracilis, stelidiis brevibus truncatis; capsula erecta ovata oblonga, ¼-uncialis.

Ceylon: Haragala, *Dr. Trimen*! Herb. Brit. Mus.

STUDIES IN VEGETABLE BIOLOGY.—IV. The Influence of Light upon Protoplasmic Movement, Part II. By SPENCER LE M. MOORE, F.L.S.

[Read 19th January, 1888.]

(PLATES XIII.–XV.)

The Movements of the Chlorophyll Bodies of Selaginella Martensii, *Spring, with some Notes on Positive and Negative Fragmentation of Chlorophyll.*

PRILLIEUX* discovered that the large undivided chlorophyll body arranged in the shape of a saddle in the lower part of each upper epidermal cell of *Selaginella Martensii* leaves assumes a lateral position when the plant is brought up to sunlight, sometimes suffering fragmentation during the process. Beyond noting that several other species of the same genus share this peculiarity, Prillieux did nothing whatever; and as no attempt has since been made to grapple with the problems involved in this movement, it is proposed to deal with the subject here.

The tetrastichous, and at first imbricated, leaves of the heteromorphic *Selaginellas* are, as is well known, of two kinds, those of the two upper rows—turned towards the source of light—being markedly smaller than their lower-lying fellows. Each leaf has an upper and a lower face; and since the long axis of the small leaves runs very nearly parallel to that of the stem, each small leaf has a right and a left edge; but the two edges of the large leaves are fore and hinder, since the long axis of these is, from an early period, at or nearly at right angles to the stem's apostrophe. The large leaves of *S. Martensii* are covered on the upper face with an epidermis of five-, six-, or even seven-sided cells with wavy borders, the angles frequently not well indicated. Similar cells are continued over the single central rib. The cells, isodiametral or nearly so in the distal and middle parts of the leaf, are at the proximal end somewhat elongated in the direction of the long axis. The fore edge is, for the greater part of its course, occupied by cells many times longer than broad; these may sometimes be studded with small bosses upon the side walls or upon the free (superficial) wall as well. There may be as many as four or five rows of these marginal cells, which are wanting at the leaf's hinder edge, the isodiametral cells under these circumstances running up to the edge to abut on a single row of narrow cells. At either edge some of the marginal cells grow out to form a tooth with lumen continuous with that of the parent; these teeth are longest near the base of the fore edge, and most numerous near the leaf's apex, where, indeed, nearly every marginal cell is dentiferous. On the underside, the cells of the proximal three-fourths are much longer than those of the upperside, except over and near the rib, where not much elongation is seen. The area of narrow bossed cells is usually deeper here than on the upperside, and it may be still further broadened in places by the apposition of wider cells with bosses upon their walls; the wider type of bossed cell may occur here and there among the ordinary cells of the underside. Stomata are placed upon the lower face on or close to the rib, their number ranging between one and two hundred: a few stomata are also found upon the hinder edge, rarely towards the distal end of the fore edge as well. In the early stages of growth the small leaves completely overlap the large ones, and the latter each other; but as the axis lengthens the large leaves diverge, each being now overlapped anteriorly by the leaf in front and similarly covering its predecessor; afterwards only the proximal half of the fore edge is covered and at length the leaves get quite clear; the slight obliquity of these leaves is due to forward extension of the leaf-tissue at the proximal part of the fore edge, a region of the leaf where the cells are several times longer than broad. The upper leaves, at first closely imbricated, are soon free from each other except for slight overlapping at the side and base, which afterwards disappears in consequence of the elongation of the stem. These leaves are more oblique than the larger ones, the obliquity being on the right side of the left and on the left side of the right leaf; but they are much like them in structure, the chief differences being that the stomata are upon the upper instead of on the under face, and that the epidermal cells in the oblique portion are isodiametral as elsewhere.

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* Comptes Rendus, tome lxxviii.

A section of a large leaf in a plane perpendicular to its own shows the cup-shaped epidermal cells of the upperside, which, having their long axis at right angles to the plane of the leaf, bear some resemblance to palisade-cells; they touch at their sides, but taper off somewhat so as to leave narrow interspaces between their inner ends (Pl. XIII. figs. 1 *a–c*). Lying upon the whole of the inner and a part of the lateral walls is the saddle-shaped chlorphyll body; thus, when looked at from above, the leaf of a healthy plant growing in diffused light presents to view a number of bright green disks separated from each other by the cell-walls. This is, however, true only of the upper three-fourths of a leaf; at its base and throughout the oblique portion the chlorophyll body is either horseshoe-shaped (fig. 2) or, as usually happens, it has undergone division, or at least shows signs of division, into a variable number of irregularly-outlined cleavage-masses, which may be quite separate from each other or remain in connection by means of a fine strand of colourless plasma (figs. 3 *a–d*). Division may be so complete in many of the proximal and oblique-portion cells and the cleavage-masses may round themselves off so perfectly that the chlorophyll then takes on very much the appearance of ordinary grains (fig. 4). Underlying the midrib are three layers of stellate mesophyll-cells with granular chlorophyll; this tissue thins out towards the leaf's edge and disappears at some little distance therefrom. The chlorophyll of the lower epidermal cells resembles that of the elongated cells of the upper layer. There is great diversity in the form assumed by the cleavage-masses, especially towards the leaf's apex—a very common condition being that of a straight or curved chain with fine connecting threads between the round chloroplasts (figs. 5 & 6 *a–d*). The chlorophyll of the small leaves is very similar, but inasmuch as the upper epidermal cells are all isodiametral or nearly so, the saddle-shaped chloroplasts are found everywhere except at the very base *.

If strong sunlight be allowed to stream upon *S. Martensii* the chlorophyll bodies can be seen after some time to undergo the remarkable changes in form described by Prillieux. Figs. 7 *a–e* and 8 *a–g* (drawn most of them after two and a half hours' insolation) will give a fairly good idea of this. In its simplest form the chlorophyll body is falcate or horseshoe-shaped, with the wider arc closely applied against a side of the cell—its position of epistrophe has been changed into one of apostrophe. If the various parts of the chlorophyll body can mutually adapt themselves, the forms just described are, so far as my experience goes, never departed from even after several hours' sunlight; but it frequently happens that contrary tendencies set in, as is shown by one part of the body moving towards one side-wall, while another or others make for another side or other sides of the cell. The consequence of this centrifugality is the assumption of very irregular forms, such as the hatchet and dumbbell, the narrow parts connecting the main masses indicating the places where, if insolation be continued long enough, the next phase, viz. actual division, will take place. To this end the chlorophyll ceases to be continuous at some part of the isthmus, and the area of separation increasing by the recession of its sundered portions, one sees two masses united by a bridge of colourless plasma, which is either of uniform width (figs. 8 *b*, *d*, and *f*) or much broader in one part than in another (figs. 8 *c* and *e*). This plasma-bridge lengthens until the side-wall is reached, but sometimes the cleavage-masses are quite isolated from each other (figs. 8 *f* and *g*). Occasionally simple contraction and rounding occurs (fig. 7 *d*). The nucleus is frequently brought into view by the fragmentation (figs. 8 *a*, *d*, *e*); but in some cases it is difficult at first sight to distinguish between nucleus and plasma-bridge (figs. 8 *c*, 10 *e* & *h*).

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* Also upon the long apiculus with which these leaves are provided.

Apostrophe and fragmentation are induced much more rapidly in the proximal than in the distal half of the leaf; but as regards time, there is some difference between leaves. Thus it is sometimes possible to trace the effect of the sun five-sixths of the way up the leaf after two and a half hours, whereas one may find leaves of which the distal cells show no sign of insolation after four hours. I have seen fragmentation in the proximal half only, and in no case have the whole of the chlorophyll bodies been fragmented or apostrophized; whatever the length of exposure to the sun, in at least a few of the apical cells no symptom of its action has asserted itself.

Selaginella Martensii is a shade-lover, consequently we should expect that if any change be caused in its chlorophyll bodies by withdrawal of light, such would not be apparent until after the lapse of some time, and this is indeed the case. In a healthy plant it is not until three or four weeks that the effect of darkness is perceived. Fig. 9 represents a chlorophyll body, still saddle-shaped, after a month and four days in the dark; its position is one of semi-apostrophe, two fine bands of colourless plasma connecting it with the wall-applied limiting layer of protoplasm*. But in leaves exposed to darkness for nine weeks greater changes are visible. We may now see the chlorophyll body, much reduced in size, marked by great irregularity of outline, and usually consisting of a narrow isthmus connecting two portions of chlorophyll (figs. 10 *a*, *c*, *d*, *f*). In some cells the threatened fragmentation ("negative" fragmentation) has actually ensued (figs. 10 *e*, *f*, *h*, *i*). Fig. 10 *g* shows a semilunar chlorophyll-body, the outer border of which was near to a side wall, and the position of the body represented by fig. 10 *b* plainly hints at apostrophe; but this position is not generally assumed even after nine weeks. This is, perhaps, no cause for surprise, inasmuch as fragmentation in sunlight has been shown to precede apostrophe.

In very young leaves a faint tinge of chlorophyll may be observed over the whole or a part only of the cell's lumen; it appears to be always one mass. The cells of the lower epidermis enlarge more rapidly than the chlorophyll body, the latter soon taking the form of a band stretching across the lumen, or of a rim at its side. This applies also to the elongated cells of the upper epidermis; the chlorophyll bodies of its isodiametral cells, however, increase in size at approximately the same rate as do the cells themselves. I am therefore disposed to think that the inseparation of the chlorophyll is the result of the failure of the isodiametral cells to stretch in the direction of the growth-axis; and this supposition is strengthened when it is remembered that positive fragmentation† is more readily brought about in the lower part of the leaf, where the isodiametral cells are larger, than near the apex. Now, the occurrence of chlorophyll bodies in a group so high in the scale as *Selaginellaceæ* is quite exceptional; hence *S. Martensii* would seem to be the descendant of some longer-leaved type *, for it surely is at least rash to argue that by natural selection or otherwise the amount of chlorophyll in the isodiametral cells has been increased, in face of the fact that the long cells certainly contain no superabundance of that substance.

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* On a hasty view these bands may be taken for plasmolytic threads, which, of course, they are not, as can be seen on plasmolyzing the cell.

† Possibly negative as well; but I have no notes upon this point.

Since *S. Martensii* flourishes in the shade, it might safely be predicted that direct sunlight is not necessary in order to cause change in the position of its chlorophyll bodies. The accompanying diagram shows all the information I have been able to collect regarding the plant's epistrophic interval. The position of the positive critical point was fixed by laying out leaves under precisely similar circumstances to those detailed in the former memoir; with each set were placed some healthy leaves of *Funaria hygrometrica*, Linn. †. The duration of the experiment was two hours, ample time for apostrophe to have declared itself in the lowest of the proximal isodiametral cells close to the oblique portion of the large leaves. There is nothing to add at present; I cannot even say whether or no the epistrophic interval runs up to the negative end of the photrum—a plant with negatively (partially or entirely) fragmented and occasionally apostrophized chlorophyll, which was placed in the lowest light, with a view to ascertain

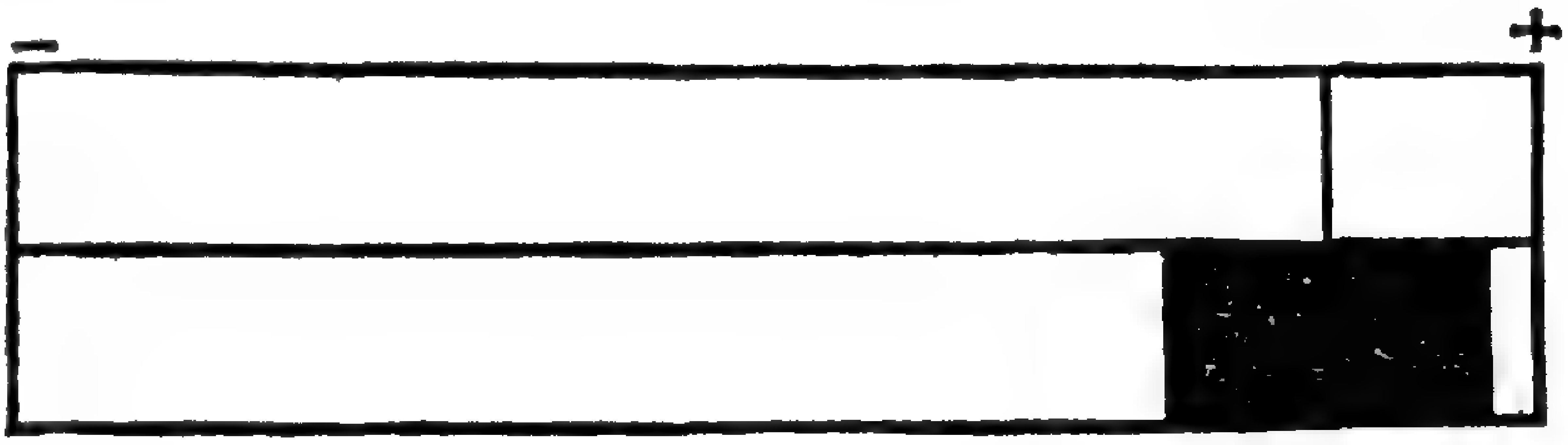

Diagram showing the positive critical point of *Selaginella Martensii*; below it the epistrophic interval of *Funaria hygrometrica* on the same day (in August) and during the same hours.

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* I do not know whether there are species of *Selaginella* with leaves having a long-celled upper epidermis and fragmented chlorophyll, and others with very short leaves provided, like the small leaves of *S. Martensii*, with isodiametral upper epidermal cells throughout. This matter is perhaps worth inquiring into.

† In the former memoir (Journ. Linn. Soc. Bot. xxiv. 1887, pp. 200–251), it was stated that the epistrophic interval of *F. hygrometrica*, there drawn (in autumn) as reaching the positive end of the photrum, would probably be found during the summer months not to reach so far to the right. This surmise has proved correct; at least for the month of August.

whether epistrophe would show itself, having, unfortunately, perished from drought during my absence from home *.

We have seen that the chlorophyll body of *Selaginella Martensii* may break up in sunlight and in darkness, and I shall now show that this is not a peculiarity of that type. The chlorophyll bodies of the larger cells of *Draparnaldia glomerata*, Ag., are arranged in a ring round the wall halfway up the cell. From the ring narrow, straight, or curved processes are given off which pass upwards and downwards, sometimes reaching to the cell's bounding walls (figs. 11 *a, b*). Instead of being continuous, the ring may consist of a number of hollow spaces bounded by slender threads of chlorophyll; it then presents a reticulate aspect. The chlorophyll body is pale green; scattered through it are a few pyrenoids. Forty-eight hours' sojourn in the dark may suffice to cause great changes, for in some of the cells the processes are now seen to be greatly shortened, in consequence of which the ring has become more or less torulose (figs. 11 *c, d*) †. After three days' darkness ‡ the chlorophyll body may form either a complete and frequently torulose ring lying across the cell at its centre or closely applied to a terminal wall, or it may have condensed into a spheroidal, subspheroidal, or irregular mass, or have undergone fragmentation into two or more masses of varying shape placed at any part of the cell, and either quite free from each other or connected by plasma-bridges (figs. 11 *e–g*), and these masses may themselves betray a tendency to division (fig. 11 *h*). After a short time even those rings which have, until now, retained their original position with respect to the cell's long axis, lose it and come to lie in any plane, sometimes reaching from corner to corner; at fig. 11 *i* is shown one of these rings, in which fragmentation has just commenced. After three days in the dark a similar disposition of the chlorophyll may be noted in the smaller axial cells; the ultimate cells at length contain either a mass of chlorophyll at their centre or at either end, or two such masses, one at the proximal, the other at the distal end.

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* A few words concerning the photric method of the former memoir will not, it is hoped, be considered out of place here. The imperfections of that method have already been dwelt upon, the chief drawback to accuracy being contracted space, especially near the right and left ends, and variations in the illuminant value of the several points in consequence of variation in the intensity of sunlight. In order to construct a series of accurate intervals, it will be necessary to employ as a standard some constant source of light of known intensity—the electric lamp should answer all requirements—in a space extensive enough to contain all grades of illumination up to perfect darkness.

† In these and the other figures only the proximal part of the ring is shown.

‡ These times apply to the summer; in autumn (October) the process is slower.

In *Chætophora* sp. the chlorophyll is disposed in the form of a central ring or irregular figure, from the borders of which broad or narrow, long or short bands extend upwards or downwards or both (figs. 12 *a* and *b*). After three days in darkness condensation has occurred in many of the cells, the chlorophyll being now in the form of a central band or *x*-shaped figure, or of one, two, or three such bands situated anywhere in the cell, or of a couple of bands at or near the centre (figs. 12 *c* and *d*). Under these latter circumstances, should the bands protrude at places, a figure somewhat similar to that in a *Zygnema*-cell results (fig. 12 *d*). The greatest change, however, is seen in some of the older cells after six days in the dark, the chlorophyll having now condensed into a spheroidal or ovoidal mass at the centre or on a side of the cell (fig. 12 *e*).

The chromatophore of *Chantransia pygmæa*, Kütz., is uniformly disposed upon the cell's walls (fig. 13 *a*); but in specimens shut up for some time from the light this arrangement is departed from in many cases. The contents are now seen to have collected either in bands or irregular figures at the proximal and distal ends of the cell, or interspaces shut off entirely or partially by cross-bridges of varying width have appeared in the chromatophore, showing that condensation has occurred at some points (figs. 13 *b*, *c*, *d*). Modifications similar, though less in degree, are to be discovered in the cells of *Batrachospermum moniliforme*, Roth, after ten weeks' darkness.

Another instance of the alteration of position wrought by withdrawal from light is furnished by the chlorophyll plate of *Mesocarpus scalaris*, Hass. In some of the cells of threads shut up in darkness for several days the only change observed is that the plate has receded from the fore and hinder ends, the chlorophyll betraying an evident tendency to collect at the centre of the cell (fig. 22 *a*). This shrinkage of the plate is frequently accompanied by its movement towards a side-wall, as will be explained further on (see p. 369). Occasionally the two halves of the plate may separate with or without an intervening plasma-bridge, in which latter—when it is absent, then in the interspace—

the nucleus can usually be made out; this is more commonly seen in *M. parvulus*, var. *angustus*, which is the subject of fig. 14 illustrating this point.

Here may be mentioned an undetermined species of *Ulothrix*, in which the chlorophyll is uniformly applied round the wall, but after a few days' darkness it masses at any part of the cell or divides into from 2 to 4 portions, which may be disposed in any way in the cell.

I have ascertained that bright sunlight is capable of causing alterations in the form of chlorophyll bodies, although but few opportunities for the study have presented themselves. So far as my observations go they show that the same effects are seen in high light as in darkness, and that much less time is required for their production. Shortening of the *Mesocarpus*-plate (fig. 20 *d*), and its collection into a ball at the cell's centre (fig. 20 *e*), was seen after 50 minutes in strong sunlight, a very peculiar effect of which is massing of the chlorophyll so as to form a couple of lenticular bodies separated from each other by a bridge of colourless granular plasma in which pyrenoids may be discovered (fig. 15). Should insolation be continued long enough, it may happen that the bridge will be disrupted and the lenses thus isolated; occasionally three lenses are formed, of which one remains near the centre of the cell. The chloroplasts of *Draparnaldia glomerata* condense into a ring of uniform calibre (fig. 16 *a*) —a prelude, but not a necessary one, to fragmentation,—which takes place just as in darkness; fig. 16 *b* shows a ring at the point of breaking; 16 *c* and *d* represent divided portions of the ring, either quite free from each other or connected by a plasma-bridge, and rounded off or constricted at places where subdivision is destined to ensue. All these figures are from a plant exposed to bright October sunlight for four hours; it must be mentioned, however, that the chlorophyll of many cells resists the tendency of high light to modify its form if only four hours be allowed for insolation.

We are thus justified in concluding that intense light and prolonged darkness act in precisely the same manner upon chlorophyll bodies. This action makes itself evident as a disturbance of the equilibrium of the bodies, inasmuch as new centres are defined around which a regrouping of the chlorophyll takes place; and not only so, but, when comparison is made between the figures of Plates XIII. and XIV. representing the normal and the positively and negatively fragmented states of the chlorophyll, it is clear that a large amount of condensation is the result of its exposure to abnormal light or darkness; this is especially well seen when contraction takes place without fragmentation, as occasionally in *Selaginella* (fig. 7 *d*), *Mesocarpus* (figs. 20 *e*, 22 *a*), and in *Chætophora* (figs. 12 *c*, *d*, *e*). It appears then that, paradoxical though it may sound, fragmentation and condensation are really the same phenomenon, the only difference between them being that in the former condensation is more violent along certain lines than along others, thus entailing disruption, whereas in the latter it proceeds equally all round. It will be necessary to refer to this point yet once more (see p. 374).

The long time taken by *Selaginella Martensii* over negative fragmentation is only what might be expected, seeing that negative effects are more slowly produced in shade-lovers than in plants with protoplasm toned to higher grades of illumination. It was shown in my previous memoir that aquatics are toned to low light: how comes it, then, that negative condensation and fragmentation are brought about with comparative rapidity in such types as *Draparnaldia* and *Chætophora*? The answer is that these latter are adapted to strong light because of their liability to be carried up to the surface of the water by bubbles of disengaged oxygen; this is an incidental advantage to the alga, because a rapid rate of assimilation is thereby assured. It is a significant fact that the chromatophore of the fixed *Batrachospermum moniliforme* and *Chantransia pygmæa* takes longer to fragment than does the chlorophyll of the above-mentioned free algæ.

But in order that the chlorophyll may condense or fragment, darkness is not essential. In low grades of illumination precisely the same effects follow as in the dark (*Draparnaldia*, *Chætophora*, *Mesocarpus*). There is therefore an interval in the photrum—which may be called the "orthotactic" interval—within which alone the chlorophyll retains its normal form. I hope to treat of this matter on a subsequent occasion.

Further Observations on Photolysis.

In my previous memoir (Journ. Linn. Soc. (Bot.) xxiv. pp. 212, 234) it was mentioned:—

I. That the chlorophyll of sun-loving types is negatively apostrophized more rapidly than that of shade-lovers and aquatics.

II. That the positively apostrophized chlorophyll of sun-lovers remains in apostrophe when removed to darkness, under which circumstances that of shade-loving plants comes out more or less into epistrophe.

During June of last year (1887) the following types were found to have the chlorophyll of their lowest layer of mesophyll [†] cells in apostrophe within twenty-four hours in darkness; those to which an * is prefixed had massed grains within the above period.

Cheiranthus Cheiri.
Capsella Bursa-pastoris.
*Platystemon californicus.
Linum grandiflorum.
Pisum sativum.
Lathyrus odoratus.
Phaseolus vulgaris.
Prunus domestica.
Petroselinum sativum.
Centaurea cyanus.
Helianthus tuberosus.
Campanula Medium.
Limnanthes Douglasii.
*Solanum nigrum.
S. tuberosum.
Spinacia oleracea.

In a few shade-lovers, on the other hand, negative apostrophe was much more slowly induced, thus:—

Viola odorata. Apostrophe still imperfect after 10 days' darkness (fig. 18).

Circæa lutetiana. Apostrophe still imperfect after 4 days' darkness.

Hedera Helix. Apostrophe still imperfect after 3 days' darkness.

Vinca minor. Apostrophe still imperfect after 3 days' darkness.

Nemophila insignis. Apostrophe partial in 24 hours; not complete in some cells after 5 days.

Mercurialis perennis. Apostrophe complete within a week or 10 days.

Polygonatum multiflorum. Apostrophe incomplete in 4 days.

Much the same story was told by four aquicolous types:—

Hypericum elodes.
Drosera rotundifolia. } Apostrophe incomplete in 4 days.
Hydrocotyle vulgaris.

Potamogeton crispus. Apostrophe at tip of leaf nearly perfect within 24 hours; but subsequent stages very slow, so that the movement had not been completed in eight days; further down the leaf progress is still lower.

The Ranunculuses might at first sight seem to be exceptional, that is if *R. sceleratus* and *R. bulbosus* are to be taken as types of the behaviour of their congeners; in both of them apostrophe was incomplete after three days in the dark, though in the former the grains had, within this period, massed to some extent in the cells' arms. *R. sceleratus*, however, should perhaps have been included in the list with *Hypericum elodes*, as both affect similar localities; and I am disposed to regard *R. bulbosus* as essentially a shade-lover, for its leaves, almost all radical ones, are commonly hidden away among glass-blades, so as to be but little exposed to direct sunlight; the same explanation was advanced in the former memoir *à propos* of the tardy apostrophe of *Saxifraga granulata* chlorophyll. Another apparent exception is *Tropæolum majus*, with apostrophe still imperfect after three days' darkness; but seeing that this is a climber, and as such liable to be overshadowed by its supporting plant, we might expect to find its protoplasm toned to the lower grades of illumination, although it appears from the first of the above lists that this is not the case with the much faster-growing *Pisum sativum* and *Lathyrus odoratus*.

[†] Here and elsewhere I have used this term to denote all the internal thin-walled parenchymatous elements of the leaf except palisade-tissue and bundle-sheath.

In confirmation of the second statement the few facts which follow may be cited:—

Hydrocotyle vulgaris. Chlorophyll positively apostrophized, insolation being continued for seven hours. Three days afterwards—the plant having meanwhile remained in darkness—many of the grains were in epistrophe.

Polygonatum multiflorum. A cut shoot with positively apostrophized chlorophyll, examined after six days' subsequent exposure to the dark, had most of the grains in epistrophe.

A plant of *Viola odorata* was set in sunlight for six hours, and then placed in the dark chamber; forty-two hours thereafter almost all the chlorophyll was epistrophized.

The two following experiments, made in July, are also in point:—In the first of these, *Viola odorata*, *Polygonatum multiflorum*, Ivy, and *Circæa lutetiana* were the shade-loving types, and *Senecio vulgaris* and *Campanula Medium* the sun-loving ones. They were all set in brilliant sunlight for three hours, and after remaining twenty hours in darkness, it was found that whereas the chlorophyll of the sun-lovers' lowest mesophyll-layer was still in apostrophe, in the others more or less epistrophe had declared itself. The second experiment resulted similarly, *Viola odorata*, *Polygonatum multiflorum*, and *Circæa lutetiana* serving in this as before and a young vigorous wallflower plant doing duty as a sun-lover.

It was shown in the previous memoir that *Lemna trisulca* is exceptional, inasmuch as in this type the negative apostrophe is almost completed in a very short time, although a few grains remain in epistrophe days after. Much the same thing is seen in the mesophyll of *Circæa lutetiana* and also in *Potamogeton crispus*. Moreover, after positive apostrophe, epistrophe is only very partially induced in darkness with these three. Perhaps the peculiarity as affecting *Circæa lutetiana* may be in part due to the small amount of chlorophyll in its mesophyll-cells, and the consequently unimpeded progress of the grains towards the side-walls. But I am inclined to think that when its tissues are exceptionally transparent, although a plant may be a shade-lover, yet its protoplasm is toned to higher grades of illumination than would be the case were the leaves more opaque.

It was also shown that the chlorophyll of palisade-tissues is far more movable than had hitherto been supposed; and, moreover, that the grains can be made to mass in darkness. I have observed positive massing in *Viola odorata* after between three and four hours' insolation; not only are the masses on the side-walls, but they may occasionally be seen closely covering the lower wall instead of, as is the case in diffused light, presenting in bird's-eye view a sort of tunnel lined all round with chloroplasts. In some of the palisade-cells of *Convolvulus arvensis*, *Platystemon californicus*, and *Hydrocotyle vulgaris* massing occurred after 4 hours in sunlight; in *Chrysanthemum segetum*, *Tropæolum majus*, and *Matthiola incana* after 6 hours; and in some of the large subepidermal cells of *Hydrocharis Morsus-ranæ* after prolonged insolation. On the other hand, it required 3 days' darkness to effect much alteration in the position of the chlorophyll of *Viola odorata*: in darkness, as well as in sunlight, the grains of this type may sometimes be seen massed upon the lower wall (fig. 17). Negative massing was also found in *Cheiranthus Cheiri* after 2¾ days in the dark, in *Hydrocharis Morsus-ranæ* after a week, and after varying periods of confinement in many others, including *Senecio vulgaris*, *Primula vulgaris*, *Godetia rubicunda*, *Hibiscus africanus*, &c. The palisade-chloroplasts of *Circæa lutetiana* were found collected into masses after confinement for five days, during which period those of the subjacent mesophyll-cells showed no tendency to mass.

A few words may be here added as to the method of examination resorted to in the above and similar cases. I have discarded, with one exception, all other practice in favour of simple sections with the razor, taking care not to make the section too thin and thereby destroy the cells. Thus prepared, cells may be mounted in water rapidly; and for some time they will retain their vitality and betray no change in the position of and no injury to the chlorophyll. The exception is where, in examining the lowest mesophyll layer, this can be detached without injury along with its epidermis by simply tearing off pieces of the latter. The only two species admitting of this treatment are, as far as I have hitherto found, *Viola odorata* and (much less favourably) *Oxalis Acetosella*: these are both shade-lovers; could a similarly behaving sun-lover be discovered, the photolytic differences between the two groups could be demonstrated to a whole class within a few minutes.

The "Activity or Passivity" Question.

The behaviour of the chlorophyll of epidermal cells in the sun's rays and in darkness throws a great deal of light upon the vexed question of the activity or passivity of the chlorophyll grains in photolysis. During the past summer I have had many opportunities of studying the epidermal chlorophyll of insolated leaves attached to or detached from the parent, and either free in the air or covered with a glass slide under water frequently renewed. In almost all cases[1]—*Viola odorata*, †*Circæa Lutetiana*, *Chrysanthemum Matricaria*, *C. segetum*, *Pyrethrum Parthenium*, **Bellis perennis*, *Achillæa Millefolium*, 0 *Helianthus tuberosus*, **Solanum Dulcamara*, **S. tuberosum*, 0*Anagallis arvensis*, †*Mercurialis annua*, among others—no change was observed in the position of the grains even after several hours' direct sunlight—that is, long after apostrophe had set in in the deeper cells; and even in the epidermis of *Hydrocharis Morsus-ranæ* no tendency to apostrophe was detected after seven hours' insolation. Occasionally a cell might be met with in which a few, very rarely all, of its grains were found upon the side-walls; but so seldom is this seen, that it may well be questioned whether positive apostrophe is really a contingency in the history of epidermal chlorophyll. Similarly, in darkness the grains do not perceptibly apostrophize, even long after those of the mesophyll have done so. *Clematis florida*, †*Circæa Lutetiana*, **Bellis perennis*, *Achillæa Millefolium*, *Chrysanthemum Matricaria*, †*Helianthus annuus*, 0*Lactuca sativa*, 0*Anagallis arvensis*, †*Mercurialis annua*, and others may be adduced in support of this statement, not the least trace of apostrophe having shown itself in their epidermis after three days' darkness. The chlorophyll, however, sometimes appears to slowly shift its position. In the previous memoir I described massing of the epidermal grains of *Pteris serrulata* after three weeks in the dark, and confinement for a week caused in the epidermis of *Hydrocharis Morsusranæ* massing in an angle of the cell or on the free (superficial) wall: moreover, in some cases nuclear massing was observed. But Stöhr[1] states that the natural position of epidermal chlorophyll is either upon a front wall or in the immediate neighbourhood of the nucleus; and I am inclined to support him, believing that the nuclear massing in these cells is not an effect of light or its absence, or at most is but obscurely related thereto, seeing that not only may it be seen in dark-loving plants, but under any conditions of illumination as well.

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[1] The names marked with an * are those of plants of which the epidermal chlorophyll contains starch; the † is prefixed to species with but slight traces; and the 0 to those with no trace of starch in the chloroplasts of their epidermal cells.

There is therefore no alternative but the conclusion that if apostrophe (negative or positive) be manifested in epidermal cells, it is exceedingly rare. Could a stronger argument be adduced against the doctrine that the chloroplasts contribute to these movements? It might indeed be urged that epidermal chlorophyll is in some respects different from that of the underlying cells, since Stöhr[2] declares that starch cannot be detected in it. This, however, traverses De Bary's[3] statement that epidermal chloroplasts "eventually" contain starch. I have endeavoured[4] to show both these views to be incorrect; for not only are there many species (42 per cent. of those examined) with starchless epidermal chlorophyll throughout life; but the grains of species with vigorously assimilating chlorophyll[5] can readily be disamidated in darkness and recharged with starch in light. Now the two lists just given include the names of species (i.) with plenty, (ii.) with traces, and (iii.) with no signs of starch in the chloroplasts of their epidermis; consequently the movements of the latter are not dependent upon their capacity for assimilation.

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[1] Sitzb. derk. k. Akad. Wien, 1879. [2] *Op. cit.*

[3] Vergl. Anat. p. 70. English Edition, p. 66.

[4] Journ. of Bot., Dec. 1887.

[5] I speak in the conventional sense, without any special reference to Pringsheim's theory.

If the objection were raised that the argument here used, when carried to its logical conclusion, would militate as strongly against Sachs's view, that the cause of photolysis is to be referred exclusively to the movements of protoplasm, the answer would, it is apprehended, be somewhat as follows:—It is true that the epidermal cells, having in most species a nucleus, a protoplasmic reticulum, and chloroplasts, do not differ in any essential feature from ordinary cells; but it is no less clear that, whether from an originally small supply or from the great stretching undergone, the relative quantity of protoplasm contained in them is very small. In my previous memoir the dependence of photolysis upon protoplasmic momentum on the one hand, and inertia of the chlorophyll on the other, was (it is hoped correctly) explained. It is therefore no matter for surprise if, in face of the diminution of one of the two factors of this momentum, viz. the mass, photolytic phenomena should be in abeyance. It might perhaps be safe to go further than this and maintain that the protoplasm is incapable of moving the grains because, whether from the exhaustive calls upon it in connection with the thickening of a wall or walls, from the injurious effects (frequently observed) of continued sunlight or other causes, its capacity for movement has been diminished or lost. I am also inclined to believe, as no other alternative suggests itself, that in those epidermal cells well provided with apparently healthy chlorophyll without starchy contents, the deficient factor is protoplasmic energy; and if this be correct, the failure of photolysis to come off in epidermal tissues is easily understood. At any rate, it is submitted that, in view of its inability to stand the crucial test here applied to it, the "activity" doctrine should henceforth be dismissed from Vegetable Physiology.

Light and the Chlorophyll Plate of Mesocarpus.

Stahl[*] is our creditor in respect of some beautiful discoveries of the movement of the chlorophyll plate of *Mesocarpus scalaris*, Hass. His observations may thus be summarized:—

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[*] Bot. Zeitung, 1880, p. 299, &c.

(i.) In diffused light the chlorophyll plate places itself at right angles to the incident light: very poor grades of illumination can excite this movement.

(ii.) In sunlight the edge of the plate is turned towards the source of illumination.

(iii.) On continued insolation, the plate, straight till now, assumes a curved figure.

I am not quite sure if I rightly interpret Stahl's views on the first of these points. What I find is this:—If a *Mesocarpus scalaris** plate be placed so as to receive from two sources rays of diffused light in planes at right angles to each other, and if it have originally been face up (fig. 19 *b*) to the rays having the greater intensity, it will remain in this position; but should its edge have been shown to the stronger rays (fig. 19 *a*), it will, after a short time, turn round upon its axis through 90°, so as to face them. Obviously there is more here than a mere setting broadside on to diffused light; because if a similar experiment be arranged, but so that the lower intensity of the former occasion be the higher one of this, it will be found that the plate will turn so as to face these rays of higher intensity; in other words, it places itself in such a position as to cut the greatest possible number of rays of diffused light of the highest illuminating value. There is something in this suggestive of the behaviour of a piece of soft iron in gathering up the greatest number of "lines of force" when placed in a magnetic field.

The time required by the movement to complete itself appears to vary inversely as the intensity of light. Thus, during the month of August last the following average values were obtained:—

In good diffused light the plate swings round in 7 minutes.
In medium ,, ,, ,, 15–20 ,,
In lowest ,, ,, ,, $1\frac{1}{2}$–2 hours.

To the dictum that the plate turns edge up to sunlight I have some objection to take. The result of many experiments made during the past summer in strong sunlight left me no alternative but to decide that Stahl had misread his text *in toto*; but a resurvey of the ground in October has convinced me that he is correct, but only so far as weak sunlight is concerned, under which circumstances, on several occasions, I saw the broadside plate slowly turn over and take up its position along the axis of the cell, the only difference observable between this movement and that in diffused light being the longer time required—from 20 minutes to half an hour as against 10 minutes; and the only effect of continued insolation was to cause the appearance of curves in the plate. In strong sunlight*, however, the turning movement is in abeyance, as reference to figs. 20 *a–e* will show. The first of these (fig. 20 *a*) indicates the approach of either half of the plate to a side-wall; but as the relation is to opposite sides, a curved figure ensues, the central part of which remains in its original position †. Fig. 20 *b* shows a plate of which both halves have been similarly affected, in consequence of which it has moored itself to one of the side-walls, where, however, it still lies face up, its position before insolation: at a further stage the plate has turned round upon the side-wall, thus completing its apostrophe (fig. 20 *c*). The effects of the sun may sometimes be more violent than this; for instead of one half of the plate being forced to one side of the cell and the other to the opposite wall, this difference may manifest itself in the same half, the upshot of which is a sigmoid figure (fig. 21 *b*); or while the centre of the plate is urged to one wall, the two ends make for the other, whereby the form of a wide saddle is produced (fig. 21 *a*). In all this there is nothing but what might be expected *à priori*, given a long and wide chloroplast and an alternative position in the cell; it finds its analogue in the streaming movements over the illuminated (superficial) walls of the cells of insolated *Elodea*-leaves, movements which may even continue for a little time after rotation has declared itself. These figures, which take from a half to one hour to produce, are not pathological; for they are abolished after some time in diffused light, likewise within twenty-four hours in darkness, and the re-formed plate is unimpaired, as is proved by its capacity to swing round just as before insolation.

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* I have called the subject of the following researches *M. scalaris*; and I believe the determination to be correct. In former years I have obtained *M. pleurocarpus*, De Bary (recognized immediately by the geniculate junctions of the threads), from the pond which furnished the specimens used this year, between which no junctions were found. But for this difference the two species are very much alike, except during conjugation, which I have not been fortunate enough to see in either.

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* In autumn as well as in summer.

† Compare this with fig. 7 *c*, which shows the same thing in *Selaginella Martensii*.

The plate's contraction in sunlight and the formation of lenticular bodies have already been adverted to (see p. 359).

It appears, then, that in strong sunlight the chlorophyll plate is apostrophized, and that apostrophe makes way for epistrophe in diffused light and darkness. It might further be expected that negative apostrophe succeeds epistrophe, and clear indications have been obtained in proof thereof. The effects of darkness on the plate are shown in figs. 22 *b–d*. Here fig. *b* is that of an apostrophized plate lying face up, the position it occupied before confinement: in fig. *c* apostrophe is more pronounced, while curves are seen in the plates of fig. *d*, and the nucleus has been pushed up to the wall. These figures are taken from a specimen shut up for fourteen days in October; but in summer the movement is much more rapid; indeed, in one case I found sickle- and L-shaped figures, and others like that of fig. 20 *a*, after only nineteen hours in the dark, but this is quite exceptional. It is only until three (exceptionally two) days that the apostrophizing effect of darkness becomes visible: recovery in diffused light is more rapid—from forty-eight hours' confinement within twenty-four hours, including the night; from fourteen days' in twenty-seven hours.

To produce negative apostrophe, however, darkness is not necessary. A few days in very poor diffused light may suffice to throw the plates into gentle curves, while at the same time movement towards a side-wall may betray itself. The curves, whether positively or negatively produced, I am inclined to explain in the same way as the sigmoid figures, of which they seem to be the earliest symptoms.

The law that positive effects require less time than negative, called in my former memoir the "law of positive progression," would seem to be departed from in this instance, seeing that the plate which in good diffused light can swing round in seven minutes, takes more than twice as long to do so in sunlight. This departure from the law is perhaps apparent merely: in other respects the law's dictates are obeyed; for not only has it been shown that the turning movement is quicker in high than in low diffused light, but the plate is much more readily apostrophized positively than negatively. In fact, we have here two totally distinct phenomena, viz. alteration in the plate's plane and apostrophe, and it has been shown that when the latter comes upon the scene, the former is in abeyance. Now apostrophe under the most favourable conditions requires at least half an hour for its completion; and there is reason to believe that the swinging movements in sunlight are associated with apostrophic ones. Ought it therefore to be a matter for wonder that these movements are performed in periods intermediate between those required for the turning of the plate under the most favourable circumstances in diffused light and those necessary for the production of apostrophe?

Of light as a fructifying cause, *Mesocarpus* affords an interesting example. This is shown in two ways: if a specimen be so arranged that, the plate having been in full face, considerable approaches are making towards the profile position, or *vice versâ*, on plunging now into darkness and examining after a short interval, the movement will be found to have been almost or entirely completed. A second instance is yielded by the behaviour of the plate in darkness. I find that correct prediction as to the position (face or edge up) which any given plate will occupy after a few hours' withdrawal of light is impossible; for in some of the cells the plates which previously lay face up will now show their edge, and *vice versâ*; indeed, difference is frequently observed even in neighbouring cells. These variations I venture to explain on the view that a registration of the impulses of light goes on in the chloroplast, so many urging the plate into one plane and so many into the other. Should the two sets of impulses be equal, then no swinging movement ensues; but if one set predominate, the plate turns accordingly.

It is submitted, then, that—

(1) In diffused light the chlorophyll plate of *Mesocarpus* sets itself so as to cut the greatest number of light-rays of the highest intensity. The time occupied by the turning movement varies inversely as the strength of the illumination.

(2) In weak sunlight the plate turns edge up; but the effect of strong insolation is to drive it into apostrophe: when different sides of the cell are approached by different parts of the plate, then sigmoid and saddle-shaped figures result.

(3) The plate can be negatively apostrophized, but only after the lapse of a period much longer than is necessary for positive apostrophe to declare itself; the negative movement comes off in low light as well as in darkness.

(4) When the turning movement is in progress, it will not be

stopped in the dark if light have imparted sufficient impetus to the plate.

(5) In darkness the plate may turn so as to remain either face up or on its edge. The position ultimately assumed depends on the accumulated (potential) effects of light.

On Chlorophyll Figures. (Preliminary Notice.)

It was stated in the former memoir that prolonged insolation, as Stahl showed, causes the chlorophyll to mass in the corners of the cells (mesophyll of *Oxalis Acetosella*[*] &c.). It was also shown that the same thing occurs upon long-continued withholding of light; and when remarking on this, in connection with *Eschscholtzia californica*, it was noted that the grains lie so closely together as to be liable, but for their colour, to be taken for local thickenings of the wall—a very different state of things from that portrayed by Stahl, where the grains, although near together, are far from being so closely crowded as to give this impression. Had Stahl continued the insolation, he would have found that these *massed* grains touch and then adhere to each other ("*cohesion*"), and might further be so firmly welded together as apparently to lose their individuality—thus exhibiting what it is proposed to call "*coalescence.*"

Senecio vulgaris is a very good type for the study of this curious phenomenon; the only requisite is a brilliant day with sunshine (for five or six hours) as strong and unintermittent as possible. Fig. 23 *a* shows a *Nostoc*-like chain of cohering granules seen, in bird's-eye view, lying across the lumen of a palisade-cell of a *S. vulgaris* set for several hours in strong, but in this case intermittent, sunlight. Cohesion is here very well pronounced; but it is doubtful if coalescence has set in, for there were dark lines between the grains, except in one instance, it is true: whether, however, this latter is a result of coalescence, or is a representative of a single grain in course of division, it is impossible to say. From the palisade-tissue was also derived fig. 23 *b*, where the sun's action has led to the formation of an *Ophiocytium*-like mass of chlorophyll in which cohesion was plainly betrayed, but in which I failed to obtain satisfactory evidence of coalescence, except at the narrow portion, where it

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[*] Stahl, Bot. Zeitung, 1880. The figure alluded to is well known from its reproduction in the general works of Sachs and Pfeffer.

has apparently set in. The mesophyll is, however, the best tissue for the present purpose. At fig. 24 is shown a chlorophyll mass whereof nearly one half was composed of grains forming by their coalescence an irregularly outlined figure, the remaining grains merely cohering together. A view of an entire mesophyll-cell is given in fig. 25; this shows grains in several places so completely coalesced, that it was impossible with the best focussing to resolve the mass into its constituent portions—at another spot (marked *coh*) perhaps cohering, though possibly only closely massed; and at one point in simple apostrophe. The figures formed by the coalesced chlorophyll grains are very various; indeed, they depend upon the form and extent of the cell's arms, in which they lie pressed together so tightly that the original lines of separation have vanished. As another instance of this may be cited the mesophyll of *Solanum nigrum* (fig. 27) after seven and a half hours' insolation. In this figure the grains in the cell's arm have to all appearance coalesced, while those in the immediate neighbourhood were in cohesion. Similar facts were observed in a number of types, among others ***Reseda odorata*** and ***Circæa lutetiana*** upon seven hours', and ***Nigella damascena, Mathiola incana***, and ***Tropæolum majus*** after six hours' insolation.

It is necessary to add that great caution is required before determining that the chlorophyll grains have really coalesced, as in many cases of apparent coalescence more careful examination teaches that cohesion, or sometimes mere massing, is alone in question: this is especially frequent when the presumed coalesced mass stands side up to the observer, since a number of grains closely packed one behind the other may produce an impression of solidarity which, as surface-views may show, is far from being the actual state of affairs. A satisfactory proof of coalescence is furnished by what it is proposed to call "chlorophyll figures:" these are obtained by teasing out in water small pieces or sections of leaves previously exposed to sunlight for several hours, under which circumstances among the numerous single chloroplasts may here and there be found floating masses of chlorophyll much larger than individual grains, and sometimes still retaining, in spite of the action of the water, the form impressed upon them by the limits of the space within which they were packed. Such is the source of figs. 26 *a–c*, taken from a leaf of ***Senecio vulgaris*** insolated for seven and a half hours. It must be confessed, however, that the number of these escaped masses is not so great as might be expected: this is probably due to difficulty in dislodging them from the cells without injury.

If a leaf of *Vallisneria spiralis* be cut off and set in water in a shallow vessel exposed to bright sunlight, the protoplasm both of the superficial and deep cells soon begins to rotate, the chlorophyll being carried along with the stream. This movement will continue for some time; but in long-continued sunlight it eventually comes to an end, a prelude to the destruction of the protoplasm whereof this is the first visible sign. In cells with this light-stiffened protoplasm it is usual to find the chlorophyll massed upon any wall, frequently round the nucleus; and careful examination will show that the originally round grains have become polyhedral by mutual pressure (fig. 28 *a*). By prolonging the insolation—any recovery in diffused light (supposing the protoplasm to be capable of such) being prevented by setting the leaf in darkness overnight and retaining it there ready for removal to sunlight on the morrow—the massed grains can be seen first to cohere, and ultimately in some cases to coalesce into figures of variable shape, occasionally forming a beautiful lattice-work extending over a small part or almost the whole of the cell (figs. 28 *b*–*e*). Destruction of the protoplasm is accompanied*—never, I believe, preceded—by discoloration of the chlorophyll, which still retains, for some time at least, the forms impressed upon it by virtue of the coalescence of its grains. The ultimate fate of the coalesced masses was not ascertained.

Although less expeditious, it is easier to study this phenomenon from the negative side, because the requisite conditions, obtained with so much difficulty when the agency of sunlight is invoked, can always be readily commanded. *Helianthus annuus* is a convenient type, though almost any plant† will answer the purpose. A small mesophyll cell of this species from a plant confined to darkness for forty-one hours is represented at fig. 29 *a*: it shows the chlorophyll coalesced into four masses in the cell's arms; two, being broadside on, have stood the test of the fullest examination; in the other two, which are somewhat in profile, there seems no doubt of coalescence, although faint indications of the grains are visible in both: the small mass upon the left shows very incomplete coalescence, if, indeed, mere cohesion be overstepped. Similar appearances were obtained from, among many others, wallflower mesophyll, after $2\frac{3}{4}$ days' darkness, by which time coalescence was setting-in in cells of the palisade-tissue; *Bryonia dioica* (four days), *Hydrocotyle vulgaris* (a fortnight), *Senecio vulgaris*, *Eschscholtzia californica*, &c. In some of the palisade-cells of *Hydrocharis Morsus-ranæ* the grains seemed to have coalesced after a week in the dark—at least it was found impossible to fully resolve the mass into its constituents. Such cases are, however, unsatisfactory, owing to the small size of the grains and the consequent difficulty in seeing them properly.

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* Perhaps followed; for it is difficult to say exactly when the protoplasm actually dies.

† A sun-lover should be selected, because negative apostrophe and massing are readily induced in such.

As in *Vallisneria*, the grains, when they come into close relation, become polygonal by mutual pressure*. Extreme instances of this will be seen on reference to fig. 29 *b* (*Helianthus annuus*) and fig. 31 (*Bryonia dioica*), each representing an arm of a mesophyll-cell in broadside view. In the first of these there are five grains, of which the central one has been greatly reduced in size and rendered rectangular by the pressure of its four trapezoidal neighbours. Lines of division are still to be made out, although it is possible that some amount of coalescence may have taken place. Fig. 31 shows the grains closely cohering, and perhaps in incipient coalescence, though this could hardly be the case if the well-defined white cross be, as I suspect, cell-protoplasm separating four grains†.

Comparing figures of the chlorophyll body of *Selaginella Martensii* (figs. 1 *a*, *b*, *c*) with those of coalescing chlorophyll grains (figs. 25 & 29), it is seen that in all there is a quantity of amorphous chlorophyll contained in a limited space. Reason has been given for the supposition that if the upper-layer cells of a *Selaginella* leaf could stretch, fragmentation of the chlorophyll would ensue; and the same result we know happens when the pressure is relieved from coalescent chlorophyll by exposing it to epistrophizing grades of illumination. Is there justification for going further than this, and holding that the massing (positive or negative) of mesophyll and palisade chlorophyll is merely a phenomenon of fragmentation? If so, the whole matter should perhaps be viewed somewhat in this way:—In diffused light of medium strength the previously aggregated protoplasm spreads itself out upon the cell-wall, moving in the direction of least resistance to do so. [Upon this point see also p. 380.] Should this direction be such that the aggregates are drawn towards one another, the chlorophyll not being differentiated from the protoplasm, coalescence ensues, and a single chlorophyll body is formed in each cell (*Selaginella*, *Draparnaldia*); but if the chlorophyll has undergone differentiation from the protoplasm, release of the latter from pressure must clearly be followed by separation of the several chlorophyll masses.

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* On a subsequent occasion I hope to discuss this yielding to pressure in connection with the presumed dependence of the size and form of chlorophyll grains upon insolation.

† I greatly regret not having solved the doubt upon this point; its importance escaped me until it was too late in the year to repeat the experiment.

Mention should here be made of the late Charles Darwin's* discovery of the "aggregation" of chlorophyll grains of *Dionæa muscipula* and other types upon their exposure to weak solutions of ammonium salts. Darwin has furnished evidence tending to show that the grains, even when aggregated beyond all possibility of individual recognition, can be regenerated—a proof that any changes caused in the grains themselves by the salt cannot be very far-reaching. Is it possible that protoplasmic movement is at the bottom of this, as it is of the coalescence in sunlight and darkness? An enhanced rate of streaming was directly observed by Francis Darwin† and by H. de Vries‡ in the cells of *Drosera* tentacles lying in solutions of carbonate of ammonia; and should the streams converge towards certain points, it is easy to understand how the grains would be driven into a heap, and thus prepared for becoming firmly welded. Perhaps in this case, and also when coalescence ensues in sunlight or darkness, contact induces some slight change in the grains whereby they become weldable, as impacts of relatively great violence without any supervening coalescence can occur between grains of *Elodea canadensis* suddenly set in bright sunlight. But the whole subject is as obscure as it is interesting.

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* Journ. Linn. Soc., Bot. vol. xix. p. 266.

† Quart. Journ. Microsc. Sc. 1876, p. 309 &c.

‡ Bot. Zeitung, 1886, p. 1 &c.

On the Lateral Position of the Chlorophyll of Palisade-Cells.

An interesting problem is propounded when it is asked, What is the reason that we find the chlorophyll of palisade-cells ranged upon the sides at ordinary grades of illumination? Stahl[*] supposes this to be a method whereby the chlorophyll is withdrawn from undue illumination—a doctrine vigorously assailed by Haberlandt[†], whose idea is that the position of the chlorophyll depends upon the form of the cell with this exception, that the transverse walls are left free of chlorophyll in order to facilitate the passage of assimilation-products through them. Haberlandt bases this notion upon the following chief grounds:—

(1) That in some types (*Ornithogalum nutans, O. umbellatum, Muscari racemosum, Scilla bifolia, Viola odorata, Polygonum Bistorta, Ranunculus Ficaria*) on cloudy days the transverse walls of the palisade-cells are more or less studded with chlorophyll grains, which in clear weather and in sunlight move on to the sides.

(2) That if Stahl's view be correct, we ought to find all those cells' walls parallel to the surface destitute of chlorophyll, and all perpendicular, or nearly perpendicular, walls provided therewith. This is not the case, since—

(*a*) Chlorophyll is sometimes ranged upon the lower transverse wall when this abuts upon an intercellular space.

(*b*) Cells ending freely in the respiratory chamber without reaching the epidermis have chlorophyll upon the free end.

(*c*) The cells are sometimes curved, occasionally to such an extent, that they become L-shaped; the septa intervening between the cells must obviously be either oblique or vertical when seen in transverse section. Now in the horizontal and inclined portions of these cells the chlorophyll has the same disposition as in the vertical part, while the inclined and vertical septa are denuded of chlorophyll.

Haberlandt further insists upon the more or less perfect radial symmetry of the assimilating tissues of plants with reference to the vascular bundles, by which means, together with the absence of chlorophyll from the septa, provision is made for the rapid transport of assimilated matters to the bundle-sheath.

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[*] Bot. Zeitung, 1880, p. 299 &c.

[†] Ber. d. deutschen bot. Gesell. 1886, pp. 206–236.

It is now generally agreed that the palisade-tissue is the chief locus of assimilation, the products of which pass, by the mesophyll, to the bundle-sheath, and so to the bast*. I venture to doubt, however, whether this be the whole truth of the matter. The leaf-cells of *Bryonia dioica* contain a substance (the so-called "soluble starch") blueing or purpling with iodine, and presenting certain of the reactions of tannin; it is regarded by Dufour † as a carbohydrate, by Kraus ‡ as tannin. Whatever its nature, this body is undoubtedly a product of assimilation; it is therefore an easy matter, after causing its disappearance by the aid of darkness, to ascertain the precise direction taken by it, since with weak iodine it gives a characteristic blue reaction. The epidermal cells lining the lower side of the leaf contain numerous well-coloured chlorophyll grains in which starch can be detected; the upper-layer cells are without chlorophyll §. The substance in question is discoverable, by the indicated method, not only in the mesophyll and above all in the palisade-tissue, but also in considerable quantity in both upper and lower epidermis, and likewise in the basal cell and one or two of the succeeding cells of the hairs. When a stronger solution of iodine is used, a markedly deeper purple is seen in the somewhat elongated epidermal cells overlying the vascular bundles than in the other cells. This seems to show that in addition to the downward passage of assimilated matter already adverted to, there are two subsidiary overflow streams—an upward one from the palisade region, and a lower one from the mesophyll into the upper and lower epidermis respectively, which latter tissues and the hairs would appear to be important reservoirs of assimilated material; and the accumulation of this in the cells overlying the vascular bundles indicates its transport laterally in the epidermis. If this be so, Haberlandt's case is strengthened, as a reason is now, upon his doctrine, furnished for the absence of chlorophyll from the upper transverse wall of the palisade-cells, *i. e.* the wall abutting on the epidermis. Nevertheless, I am unable to agree with this author in regarding the position occupied by chlorophyll as in any way related to the transport of nutrimental substance, and for the following reasons :—

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* On this point see Haberlandt, in Prings. Jahrb. f. wiss. Bot. xiii. 1882; Strasburger, Practicum, Pensum XVII.; Schimper, Bot. Zeitung, 1885.

† Bull. Soc. Vaud. d. Sc. Nat. 1886 (see Bot. Zeitung, 1886, p. 869).

‡ Abhandl. naturf. Gesell. Halle, 1885; briefly abstracted in Journ. R. Micros. Soc., Feb. 1886.

§ Journ. of Bot., Dec. 1887.

(1) The assimilated matter produced at or near the equator of palisade-cells not laterally connected must pass along these cells' side before arriving at a septum: they must thus move upon a chlorophyll-paved road, so that the grains cannot interpose any efficient obstacle to the passage. If the cells are in contact, lateral movement of assimilated material might occur; but the position of the chlorophyll would, on Haberlandt's hypothesis, render this difficult, if not impossible.

(2) Such a case as that shown in fig. 7 of Haberlandt's 1886 memoir* (reproduced here as fig. 33) does not harmonize with his theory so far as regards the vertical septa, since the supposed advantage derived from keeping the walls free from chlorophyll would favour a *lateral* passage of assimilated matter.

(3) The arrangement of the chlorophyll upon the periphery of palisade-cells is an expression of the fact that the greater part of the protoplasm is situated there; since, were streaming to take place from here to the transverse walls, the grains would thereby be shifted on to these walls—a very rare occurrence. Now, upon De Vries's† theory, which seems well founded and to which no objection has, I believe, been taken, the transport of assimilated matters is facilitated by circulatory and rotatory movements of protoplasm, movements in which the chlorophyll grains are passive participants. How, then, is it possible to see in the almost or entire absence of streaming from certain parts of a cell a means whereby rapid transport is effected there?

(4) Before the validity of the theory in question can be admitted, it must be shown that the chlorophyll ranged upon a cell-wall really blocks the passage of assimilated material therethrough. One difficulty in the way of accepting this view has already been adverted to: might one not as soon expect to arrest the current of a river by mooring a few boats across it, as that protoplasmic streaming should be stopped by the interposition of isolated chlorophyll grains?

(5) But the large number of exceptions to the supposed rule puts great difficulty in the way of recognizing it as such. Taking mesophyll first of all, what do we find? In diffused light of medium intensity the grains are in epistrophe, the septa being

* Ber. d. deutschen bot. Gesell. 1886.

† Bot. Zeitung, 1885.

quite free of chlorophyll. In sunlight the grains first move on to the side-walls and then into the arms, where they ultimately mass upon or near the septa. Now in sunlight assimilation is more rapid than in diffused light; but on Haberlandt's theory precisely the opposite of what occurs would have been predicted, viz. that increase in the rapidity of assimilation would be accompanied by greater facilities for—or at the very least not signalized by the interposition of obstacles to—the passage of its products from cell to cell. Again, it is a remarkable fact that when cells stretch in the plane of the leaf and not perpendicularly thereto, as is the case with many aquatics, the chlorophyll is disposed, in diffused light, upon the upper and lower walls, leaving the side-partitions free from it. Under these circumstances the assimilated matters of, say, an *Elodea*-cell are free to pass either outwards towards the edge or inwards towards the midrib, or apically towards the tip, or basally towards the bottom of the leaf. In good diffused light and in the sun's rays the grains are apostrophized and rotation sets in, the four walls previously bare being now traversed by the protoplasmic stream carrying with it the chlorophyll, and the two previously chlorophyll-studded walls being now bare. If Haberlandt's theory be correct, the products of assimilation are now free to move only upwards or downwards (*i. e.* outwards or inwards), and not laterally towards the midrib: consequently difficulties so great as to put a positive embargo on transport accompany an increased rate of assimilation. Further, Haberlandt himself cites instances of palisade-tissues, the arrangement of the chlorophyll of which is such as, upon his theory, to point to *lateral* transport as the advantage derivable therefrom. But *direct* conveyance is, according to him, ensured by, firstly, radial disposition of the assimilating tissues with respect to the vascular bundles; and secondly, absence of chlorophyll from a septum or septa nearest to the vascular bundle. One of these cases of presumed lateral transport has just been noticed; another, figured by Haberlandt*, shows the transverse septa between straight palisade-cells deprived of chlorophyll. I venture to give the following reason for this disposition. It has been shown that the chlorophyll of palisade-cells tends to mass in darkness and in the sun's rays; and seeing that photolytic movements are induced in the mesophyll-cells of the higher aerophytes at low grades of illumination, it is most probable that the grains of palisade elements shift their position in feeble light. Now in the case under notice Haberlandt found the grains collected upon the walls bounding intercellular spaces, that is on the concave walls; and it is here that, upon the mechanical doctrine advanced in the previous memoir, friction being at its maximum, we should expect massing to occur*. It is therefore my belief that Haberlandt's specimen was examined under too high or too low a grade of illumination†; in fact, substantially the same arrangement is shown in figs. 8 and 9 of my previous memoir. The fact of the departure of chlorophyll from lateral septa taking place not only in sunlight, when assimilation is enhanced, but in darkness, when it is in abeyance, proves that transport of assimilated material is in no way related thereto.

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* See fig. 8 of his 1886 memoir (*Cirsium pannonicum*).

But if Haberlandt's doctrine must be rejected, however ingenious it may appear, and if Stahl's apostrophe notion meet with the same fate, what theory will explain the facts of the case? The answer is *that the protoplasm in the course of its redistribution in a cell moves in the direction of least mechanical resistance, provided the attracting or repelling action of light impose no obstacle to such movement.* It was Velten‡ who some years ago started the least-resistance notion in explanation of the constancy of the plane of the rotating protoplasm of *Elodea* &c.; and the same reason may be adduced for the arrangement of the chlorophyll upon the upper and the lower wall when rotation has ceased. So, too, in a palisade-cell with massed chlorophyll; when illumination again becomes favourable, the heaped protoplasm tends to fill a wider area, and in so doing moves where it finds least resistance to its passage. Now the grains mass upon the side of palisade-cells, only exceptionally upon a transverse wall§; so that when the protoplasm streams out, the coefficient of friction of the moving mass against the stationary limiting layer will be highest where the side is cut by a transverse septum, and still relatively high at the point of junction of the side with an oblique septum; hence the absence of chlorophyll from the septa. Moreover, the presence of chlorophyll on the free ends of palisade-cells which run up into the respiratory chamber is readily conceivable when it is remembered that, in consequence of the way in which these cells are rounded off, inequalities in the resistance to the transference of their protoplasm are obviated or at least minimized.

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* I am inclined to extend this notion so as to embrace all cases of massing or apostrophe upon the walls bounding intercellular spaces. As cases in point, see figs. 1 and 5 of Haberlandt's 1886 memoir.

† Perhaps the sectioning practised by Haberlandt tended to drive the grains from the septa more rapidly than would otherwise have been the case.

‡ Flora, 1873.

§ As is admitted by Haberlandt himself (see 1886 memoir, p. 210).

Although it is wandering somewhat out of my way, I should like to make a short statement with respect to palisade-tissue, upon the development of which Stahl* and Pick† have shown that light has great influence, the latter going to the length of ascribing to heliotropism the frequently observed variations from the perpendicular of these cells. Haberlandt ‡ regarded the object of the perpendicularity of palisade-cells to be the increase in assimilating capacity, and their arrangement in the leaf the provision of a means whereby assimilation-products might be rapidly transported to the bundle-sheath. Heinricher §, while agreeing with the last-named that the assimilating-tissues are so arranged with reference to the vascular bundles as to ensure quick passage to the latter, finds himself allowed no option but to seek for the exciting cause in the intensity of illumination, a view to which Haberlandt ‖ has recently subscribed. Both Pick and Heinricher are agreed that perpendicularity to the leaf-plane is a hereditary character of palisade-cells, the difference between them being whether strong light can cause all the distinction between isodiametral cells or cells even elongated somewhat in the direction of the leaf's long axis and typical palisade-elements. Certain of Stahl's and Pick's figures bear out the view that this can happen; whereas Heinricher and Haberlandt maintain the effect of light to be traceable only in the further elongation of cells already having palisade form. The notion of Pick that variations from the perpendicular depend upon obliquity in the incidence of light is combated by Heinricher, who holds, and apparently with reason, that they are the result of dislocations brought about by the growth and stretching of other of the leaf-tissues.

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* Bot. Zeitung, 1880, and Jenaische Zeitsch. f. Naturwiss. 1883.

† Bot. Centralblatt, Band xi. 1882, p. 400 &c.

‡ Prings. Jahrb. f. wiss. Bot. xiii. 1882.

§ Prings. Jahrb. f. wiss. Bot. xv. 1884. Further bibliography will be found in one or other of the above memoirs.

‖ Ber. d. deutschen bot. Gesell. 1886.

The remarks which follow, embodying my own views on this subject, may possibly commend themselves to some.

(1) The almost universal occurrence of palisade-cells would seem to point to the existence of some fundamental structural principle which made itself felt as a factor in Natural Selection at a very early period in the phylogenetic history of the higher vegetation. This principle can be none other than *economy of growth.* How can the assimilating portion of the leaf be increased? Manifestly in two ways, and in two alone, viz. by superficial enlargement or by an addition to the depth of the tissue. Increase of surface entails either coincident increase of the vascular system or a less effectual means of transport for assimilation-products, both of which disadvantages are obviated by the arrangement of the cells perpendicularly to the surface.

(2) The agency whereby this perpendicularity is effected is undoubtedly light.

(3) A contingent advantage of a palisade system is the minimizing of transpiration. Moreover, the cells may possibly be to some extent protected from the injurious effects of strong sunlight, which is known to be capable of destroying the protoplasm and chlorophyll of the overlying epidermal cells.

(4) The relation of the assimilating to the transporting tissues, as maintained by Haberlandt and Heinricher, is not proven. The latter, as was before mentioned, has objected to Pick's heliotropic ideas by explaining variations from the perpendicular, in cases where the direction taken is not towards the vascular bundle, as caused by mechanical dislocation; and it seems probable that the pressures and tensions exerted by the stretching bundle-elements might lead to some such radial arrangement as that upon which Haberlandt and Heinricher rely. Moreover, the very large number of cases wherein no radial relation is manifest, forces one to adopt a purely mechanical as opposed to a nutrimental theory of cell-arrangement in the leaf.

It may be asked, if the direction of the streaming protoplasm be that of least resistance, how can the movement be regarded as phototactic? Does not the one view exclude the other? I venture to think not; and for this reason. The capacity of light to modify the form of palisade-cells is admitted on all hands. This granted, what difficulty is there in conceiving that ***the form of all cells in direct relation with light is so ordained by this agency as to ensure, upon simple mechanical principles, the maximum*** *exposure of the protoplasm to favourable, and its minimum exposure to unfavourable (positive) grades of illumination?* This, with the doctrine of tone-lowering by darkness, sectioning &c., and that of recovery from mechanical strain, leaves unexplained no photolytic phenomenon with which I am acquainted.

Some Remarks on Dr. A. F. W. Schimper's *Views.*

At the end of a long memoir in Pringsheim's 'Jahrbücher für wissenschaftliche Botanik' for 1885, Schimper has some remarks upon the movements of chlorophyll, which I regret to have overlooked. Repeating the observations of Luders * upon the running together round the nucleus of the chromatophores of certain Diatoms in sunlight so as to form a heap in the centre of the frustule, and premising that these and other displacements of chlorophyll are examples of the irritability aroused in protoplasm by variations in the intensity of light, he thinks that strong stimuli of any kind, such as intense light, darkness, sectioning, &c., cause the chlorophyll to collect in one or two masses, while weaker ones bring about a shifting of it to a wall or walls from which it was before absent: the former of these —corresponding to what I have called "massed apostrophe"—is named by Schimper "systrophe," a very convenient word †; the latter answers to epistrophe. But in addition to this "phototonic" movement—movement not governed by the direction of light and dependent upon the structure of the organ—there is another kind ("phototactic") for which the direction of incident light is the dominant consideration. It is in accordance with the latter that chlorophyll grains, arriving by phototonic action upon the side-walls, turn edge-up, and are by this means protected from the injurious effects of intense light. An additional advantage derived by chlorophyll from epistrophe, apostrophe, or systrophe is that its chemical relation to the atmosphere is thereby regulated. Access of carbonic acid is a necessary condition of assimilation; but oxygen has a destructive effect on chlorophyll. When in epistrophe, therefore, the chlorophyll is exposed as much as possible to the access of carbonic acid; but should the light become too strong, the grains are carried into parts of the cell where they are protected against the injurious action of oxygen, *i. e.* they now cease to line those walls which bound the great intercellular spaces.

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* Bot. Zeitung, 1862, p. 41, &c.

† I cannot agree with Schimper as to the difference between apostrophe and systrophe; the latter I endeavoured in the previous memoir to connect with the former by merely mechanical considerations.

Against the acceptance of these views, which I trust have been fairly abstracted, many reasons could be adduced. A few may here be not out of place. And, first, it by no means follows that because the chromatophores of diatoms mass in the centre of the cell either that this is not a phototactic phenomenon, or that no movements of the protoplasm, as such, of vascular and higher cellular types are phototactic. When account is taken of the shallowness of the frustule and the relatively low specific heat and high conductivity of its walls, it does not seem at all clear that the most effectual way of protecting the protoplasm, nucleus, and chromatophores from sunlight is not to drive them into a mass at the cell's centre. But Schimper may possibly be right in giving a phototonic interpretation to this: indeed, it would seem that *all protoplasmic movement which has the nucleus of the cell as an objective is essentially phototonic*; because in such cases we do not find that high grades of illumination cause the protoplasm to confine itself to the walls least exposed to light, and apparently for the reason that the nucleus, which is the centre of the movement, is not endowed with phototactic properties. When, however, the nucleus ceases to have this importance, the protoplasm is enabled to move upon certain walls to the exclusion of others; and it seems in the highest degree unphilosophical to hold that this selection of its path cannot be governed by phototactic necessities because, when the nucleus is the centre of the movement, phototonus alone is in question. Moreover, the argument used by Schimper, with amusing iteration, that because other agencies than light are capable of calling forth apostrophic and systrophic effects, therefore light can exert no directive action upon cell-protoplasm, is surely wide of the mark; for how can the number of causes affect the matter? And what if the view advanced in the previous memoir be correct, viz. *that the action of these other agencies is to lower the tone of the protoplasm to light, so that the same effects now ensue as would happen were the cell exposed to higher illumination, viz. apostrophe and then systrophe*?

How, too, can Schimper's doctrine account for apostrophe and systrophe *in low light*? A stimulus shock, he says, produces systrophe, a weaker one epistrophe; but a still weaker one causes —not an enhancement of epistrophic action, as ought to happen— but precisely the same result as a strong stimulus! Then there is that *crux* epistrophe (as of *Elodea* &c.) in darkness. The chlorophyll of *Elodea* is positively apostrophized, with or without rotation supervening; the plant is then set in darkness, and after being thus treated with a double dose of apostrophizing stimuli, epistrophe, strange to say, is the result! But perhaps it is not necessary to carry this criticism further.

Where Schimper really traces phototaxy, viz. in the turning edge-up of the chlorophyll grains, I am quite unable to see anything but adaptation to pressure. To take a case cited in the previous memoir,— a rotating stream in an *Elodea*-cell moving, as occasionally happens, for a short part of its course upon either the upper (outer) or lower (inner) wall. When upon a side-wall the grains are set edge-up to an observer, but immediately upon their arrival at that spot where the plane of rotation changes, they turn over upon their broad side. How can phototaxy be in point here, seeing that when the grains arrive upon a more highly illuminated wall, they expose themselves more to the sun's influence than was the case before? It will possibly be allowed that this and other considerations urged in the previous memoir, and which there is no necessity to repeat, are a sufficient answer to Schimper upon this head.

Neither does the notion anent the gaseous relations of the grains seem free from objection. It is not the case with a large number of cells, *e. g.* the palisade-tissues, that when the grains are exposed to epistrophizing grades of illumination, and are ranged upon the walls bounding intercellular spaces, they shift on to other walls when light becomes too strong. Indeed, Haberlandt's doctrine, previously referred to, is based upon a directly contrary statement, viz. that the septa of palisade-cells are free from chlorophyll, which must consequently line the walls bounding the respiratory chamber or spaces connected therewith; and we know that when the grains of these cells mass, in almost all cases they meet upon some part of the side of the cell, not upon one of its transverse walls. This does not apply to the mesophyll-cells *, the chlorophyll of which does shift on to previously unoccupied walls, since in medium diffused light the grains are set upon walls bounding intercellular spaces, wherefrom they move in sunlight on to the intercellular septa—a circumstance which would seem to imply, upon Schimper's theory, a difference in behaviour towards carbonic acid and oxygen between mesophyll- and palisade-chlorophyll, which is very unlikely. It is submitted that the mechanical reasons put forward in the previous memoir fully account for all the phenomena attendant upon systrophe. And when Schimper's idea is tested by the questions, How is it possible to predicate linear movement of a gas? and How can the removal of chlorophyll from one part of a cell to another protect it from the access of a gas readily diffusible through the wall? acquiescence therein seems quite out of the question. Altogether I fear there is but slight chance of my coming to an agreement upon these matters with this deservedly celebrated botanist.

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* Exceptions to this are some succulent types. Thus Stahl (Bot. Zeitung, 1880, p. 340) found the chlorophyll of the mesophyll-cells of *Sedum dasyphyllum* upon the walls bounding intercellular spaces after an hour's insolation. Schimper must tell us how it is that these grains escape destruction.

EXPLANATION OF THE PLATES.

[Except where otherwise stated, the drawings are not to scale.]

Plate XIII.

Figs. 1–10. *Selaginella Martensii.*

Fig. 1. Cup-shaped cells of the upper epidermal layer with the chlorophyll in its diffused-light position, from a transverse section of a leaf.

2. A horseshoe-shaped chloroplast from the base of a leaf in diffused light. This, and all the following, are surface views.

3. Fragmented or dividing chloroplasts from basal cells.

4. A basal cell; its chlorophyll has divided into four grains.

5. A lower epidermal cell with a rosary-chain of chlorophyll grains.

6. Chlorophyll bodies from the lower epidermis: *d*, grains dividing.

7. Figures illustrating the effect of two and a half hours' insolation: *a* and *b*, chloroplast apostrophized; *c*, dumb-bell chloroplast, produced by two portions being urged towards opposite walls of the cell; *d*, condensed mass, showing, however, at one point a tendency to fragmentation.

8. Various stages and forms of positive fragmentation with colourless plasma-bridges and exposed nucleus (*n*); the colourless plasma is unshaded: *d* and *e*, after four and a half hours' insolation; the rest after two and a half hours.

9. A chlorophyll body moving into negative apostrophe, but still attached by fine colourless pseudo-plasmolytic threads to the limiting layer

of protoplasm applied upon the opposite wall; one month and four days in darkness.

Fig. 10. Shows the effect of nine weeks' darkness upon the chlorophyll bodies, which in *a* and *b* are still attached by colourless threads to the cell-wall: *c* and *d*, condensed bodies betraying a tendency to fragment; *e–i* represent details in the fragmentation process (*h*, acetic methyl-green, *i*, chloriodide-of-zinc preparation); *g*, an undivided chlorophyll body in negative apostrophe. In *h* and *i*, *n* marks the disclosed nucleus.

PLATE XIV.

Draparnaldia glomerata.

Fig. 11. *a* and *b*, normal chlorophyll bodies from large axial cells; *c* and *d*, the same after forty-eight hours in darkness; *e*, *g*, and *h* show stages of fragmentation after three days in the dark; *f*, a collapsed chloroplast (three days); and *i*, a broken ring which has lost its position with respect to the growth-axis after four days' confinement. × 450.

Chætophora sp.

Fig. 12. *a* and *b*, normal chlorophyll; *c–e*, stages in its condensation (*c*, *d*, after three, *e* after six days in darkness). × 450.

Chantransia pygmæa.

Fig. 13. *a*, a healthy cell with uniformly diffused chromatophore; *b–d*, condensation of this latter after one month and two days' withdrawal from light. × 450.

Mesocarpus parvulus, var. *angustus.*

Fig. 14. A condensed and fragmented chlorophyll plate (eight days' darkness): *n*, the disclosed nucleus. × 450.

Mesocarpus scalaris.

Fig. 15. Shows one effect of strong sunlight for half an hour (August) upon the chlorophyll which has collected into a couple of lenticular masses united by colourless plasma. × 400.

Draparnaldia glomerata.

Fig. 16. Chlorophyll bodies after four hours' bright sunlight: *a*, a condensed ring; *b*, a ring near the point of disruption; *c* and *d*, fragmented rings of large axial cells; in *c*, *n* the disclosed nucleus. × 450.

Figs. 17, 18. *Viola odorata.*

Fig. 17. A palisade-cell, seen from above. The effect of three days' darkness

has been to cause most of the chlorophyll grains to collect upon the lower wall; but a few are still in the lateral position.

Fig. 18. Shows negative apostrophe still incomplete after ten days.

Figs. 19–22. *Mesocarpus scalaris.*

Fig. 19. Broadside and profile views of chlorophyll plates. × 140.

20. Positive apostrophe and positive condensation of the plates, × 140: *a*, thirty minutes', *b*, fifty minutes' insolation.

21. Figures produced by the attraction of parts of the plates to opposite sides of the cell: *a* × 450, *b* × 350.

22. Shows the effect of fourteen days' darkness (October) upon plates which were face-up before confinement: *n*, the nucleus pushed to the side-wall by the advance of the plate thither. × 140.

Plate XV.

Figs. 23–26. *Senecio vulgaris.*

Fig. 23. *a* and *b* show the effect of six hours' sunlight with short intervals of shade upon palisade-chlorophyll.

24. Coalescence in a mesophyll-cell. Same conditions as those of fig. 23. × 600.

25. A mesophyll-cell, showing coalescence in the arms, at *coh* coalescence not yet established. Same conditions as those of fig. 23.

26. Expressed chlorophyll figures obtained after several hours' exposure to the sun. × 600.

Solanum nigrum.

Fig. 27. Coalescence in the arm of a mesophyll-cell; seven and a half hours' insolation. × 600.

Vallisneria spiralis.

Fig. 28. Effects of prolonged sunlight: *a*, grains become polyhedral by mutual pressure; *b*, *c*, *e*, phases of cohesion and coalescence; *d*, grains cohering with the nucleus. × 600.

Helianthus annuus.

Fig. 29. *a*, a mesophyll-cell showing coalescence; *b*, five grains closely packed in a cell's arm. (In darkness forty-one hours.) × 600.

Senecio vulgaris.

Fig. 30. Expressed chlorophyll figures from a plant kept one week in darkness. × 600.

Bryonia dioica.

Fig. 31. Arm of a mesophyll-cell from a plant shut up nearly four days in the dark, with angular chlorophyll grains. × 600.

Eschscholtzia californica.

Fig. 32. *a*, a single chlorophyll grain; *b*, *c*, *d*, coherent grains; *e*, a small expressed chlorophyll figure. From a plant deprived of light for a week. × 600.

Scilla bifolia.

Fig. 33. Section of a leaf showing bent palisade-cells. (After Haberlandt.)

Notes on Self-fertilization and Cleistogamy in Orchids.

By HENRY N. RIDLEY, M.A., F.L.S.

[Read 16th February, 1888.]

(PLATE XVI.)

IT has long been pointed out that among the Orchids, though they are plants peculiarly modified for insect-fertilization, instances of self-fertilization are not unknown. Darwin, in his work on the 'Fertilization of Orchids,' cites ten species in which self-fertilization normally or rarely occurs, and Forbes, Fitzgerald, Cheeseman, and others have added to the list. I have little doubt but that, especially among the small green-flowered orchids of the Tropics, many more examples will be found; but this is a subject which can only be studied in the living plants, and best of all in wild plants. Unfortunately these inconspicuous-flowered orchids are not often brought to our conservatories, so that it rarely happens that a botanist can study these forms. I have recently had the opportunity of seeing one or two Brazilian orchids in the wild state which appear sometimes, at all events, to fertilize themselves; and Mr. F. W. Burbidge, of Trinity College Gardens, Dublin, has recently sent me an exceedingly interesting *Trichopilia*, which seems invariably to be cleistogamous.

The most common terrestrial orchid around Pernambuco is *Œceoclades maculata*. Lindl. (syn. *Eulophia maculata*, Reichb. f., *Angræcum maculatum*, Lindl., *Eulophidium maculatum*, Pfitzer). This plant has always been a puzzling species, as its synonymy denotes. Usually referred to the neighbourhood of *Eulophia*, Dr. Pfitzer has expressed his opinion (Entwurf. ein. Nat. Anordn. p. 87) that it is more nearly allied to the Maxillariæ. The plant grows in the woods and forests, and is more noticeable for its prettily marbled leaves than for its raceme of dull brownish flowers. The stiff lateral scape (which in one specimen I found was branched) bears somewhat distant, small, inconspicuous flowers. The sepals and petals are lurid purplish brown and connivent. The flower, as far as I have seen, does not open properly, but between the lower sepals which form the lip and the petals there is a space through which the pink-striped labellum can be seen. The lip is three-lobed; the lateral lobes erect, rounded, and blunt, the median one bifid at the apex; all are ornamented with pink stripes, and at the entrance to the short blunt spur are two little truncate lamellæ. I could not perceive any scent to the flowers nor honey in the spur. But it is evident that this plant has modifications adapted for insect fertilization. The column is short and stout, but curved. In young flowers the short, thick pollinia are in their normal position in the anther-cap; but soon the anther-cap falls off, and the pollinia still remaining attached to the rostellum by the caudicle and viscid disc fall towards till they touch the stigma and impregnate it. This method of self-fertilization is very similar to that of *Ophrys apifera*, Linn.; but the shortness of the caudicle and gland make the fertilization more certain. The plant seems to fruit very largely, hardly a flower being wasted, and the seeds are extraordinarily abundant. It is widely distributed throughout Brazil, and is one of the very few orchids yet known common to that country and to Western Africa, where it was found by Dr. Welwitsch.

TRICHOPILIA FRAGRANS, *Lindl.*, var.

A couple of sprays of this plant were sent me in December last by Mr. Burbidge, of Trinity College Gardens, Dublin, with the following note:—"For the past ten years we have had in these gardens a plant very like *Pilumna fragrans* or *P. nobilis* in habit of growth, but it has puzzled myself and two or three successive foremen in that, do what we could, we could never get it to open its flowers. The plant grows vigorously and throws up from 15 to 20 spikes every season. We have adopted the usual practices, but under no circumstances could we induce the floral segments to expand as in the normal *P. fragrans*. Another point is that the present form is totally scentless, while both *P. fragrans* and *P. nobilis* are deliciously sweet. The discovery that it was *not* fragrant led me to examine the shrouded column, and I find that this form is without doubt a cleistogamous or self-fertilizing individual." He further added that he had known capsules to be developed on the plant.

The flowers sent were, as Mr. Burbidge described, scentless and closed. The lip, though regular in form and complete, was crumpled up and convolute round the column. The column itself was in a very remarkable state. The anther was empty and lying loose in the deep clinandrium or had fallen among the perianth-segments. The pollinia were invisible, and the stelidia overlapped each other just as after fertilization, sometimes on one side and sometimes on the other, in about equal proportions, so that there was only a small round hole to denote the entrance to the stigma. Just below the lowest point of contact of the stelidia was a viscid mass exuded from the stigma. By making a longitudinal section, one could see the pollen-masses, now much disorganized, lying in the stigma and emitting many pollen-tubes. The examination of younger flowers showed the earlier stages of this phenomenon. In tolerably young buds the anther and pollinia were in their normal position on the clinandrium, but as the flower advanced the anther-cap fell off and left the pollinia exposed. These then curved over the very small tongue-shaped rostellum (the stelidia being in their normal position spread wide open) until they reached the stigma, when they adhered to it and fertilized the flower, while at the same time the stelidia closed over the stigma, pressing the pollinia well into it. This method of fertilization is very similar to that of *Œceoclades* mentioned above, and it is probably the commonest form of self-fertilization among the Vandeæ, for in this group the pollen is too tenacious to break up and fall in powder upon the stigma, as it does in some Neottieæ, and it cannot entirely fall out of the anther-cap, half-accidentally as it were, on to the stigma as occurs in some Epidendreæ, on account of its being retained in its place by the well-developed caudicle and gland.

In the *Trichopilia* I cannot doubt but that the form must be regarded as a monstrosity rather than as a variety or species. In every point but those mentioned it resembles *T. fragrans*, and the fact that the stelidia overlap each other, now on one side, now on the other, would suggest that the modification by which it has become cleistogamous is not a permanent one. It is, however, an interesting case, as it shows how very simply a plant may become self-fertilized. It is very probable that more such cases of cleistogamy would be found in orchid-houses, but that, as the flowers do not open, the plant would be looked upon as a failure and thrown away.

DENDROBIUM CHRYSEUM, *Rolfe.*

A very curious cleistogamous *Dendrobium* was shown me recently by Mr. Veitch, who had a number of plants, all similar. The stems were slender and dotted with purple at the base, the leaves narrow and numerous, the flowers solitary and somewhat pendulous on the ends of the stems, bright yellow; but all were closed and did not seem inclined to open, and, indeed, have not as yet been seen to expand at all. The petals and sepals were quite normal; the lip somewhat resembled that of *D. fimbriatum*, but with a yellow patch in the centre instead of the dark maroon eye. The column had, besides the normal filament, two similar processes, one on either side, and the anther-cap, which was long and conical and obtuse, had the loculi somewhat distant, and between them was a ridge, which suggested a trace of three anthers combined in the anther-cap, the two lateral processes being the other two filaments. The pollen was a disorganized pale honey-like mass lying on the stigma even in the youngest flower I could examine. A longitudinal section of the column showed the pollen lying on the stigma, and emitting a large mass of pollen-tubes which had found their way far down the conducting-tissue of the stigma. The rostellum, if not absolutely absent, was reduced to a very small particle. The rostellar fibro-vascular bundle was present to its termination, but beyond that there was no distinct rostellum. The flower had a scent like that of hay, but I could not detect any trace of nectar at the base of the lip.

The plant is evidently quite cleistogamous, and fertilizes itself by the slipping forward of the pollen from the clinandrium on to the unprotected stigma.

This species has been named by Mr. Rolfe in the 'Gardener's Chronicle' *D. chryseum*, and he gives a few notes about it, but does not mention its being so evidently cleistogamous. There is probably also another form which fully opens its flowers, as in the case of *D. Brymerianum*; but this form is not at present known.

SPIRANTHES AUSTRALIS, *Lindl.*

In his great work on the Orchids of Australia, Mr. Fitzgerald describes and figures this species, and mentions his surprise and interest in finding that, unlike *S. autumnalis*, Rich., this plant is self-fertilized, and it possesses no rostellum. On referring to Blume's 'Orchid. Ind. Archip.' (p. 131, t. 45. fig. 1, t. 48 D), I find he describes and figures *S. australis* under the name of *Gyrostachys pusilla*, with a distinct bifid rostellum like that of *S. autumnalis*, Rich. To reconcile these two opposing statements I examined a number of plants all referred to *S. australis* in the British Museum, and found that both authors were right. Specimens from Mussoorie, India, collected by Thomson, and Java by Lobb, have rostella like those figured by Blume; while the Australian plants collected by Caley and Robert Brown have no visible rostellum. And, what is also interesting, the specimens collected by H. O. Forbes in Timor in company with *Diuris* and *Caladenia*, typically Australian orchids, resemble the Australian species in this respect. Specimens from the Friendly Islands also agree with the Australian form. But the Japanese and Chinese plants are again different from both.

I have no doubt that the whole of these forms are self-fertilized. The pollinia in the erostellate forms are so closely approximated to the stigma that it is easy to conceive how, as Fitzgerald shows, they speedily reach the stigmatic surface. In many flowers, on carefully opening them, I find the lip full of the loose friable pollen which falls abundantly into the hollow of the labellum which wraps the short thick column. I may add that, on examining the flower-spikes that are in fruit, it is seen that all the flowers are fertilized, which is not commonly the case where insect-fertilization is required.

There seem to be four common methods of self-fertilization among Orchids:—

1. By breaking up of the pollen-mass and the falling of the dust either directly upon the stigma or into the lip, whence it comes into contact with the stigma. This, of course, can only happen in the case of orchids with pulverulent pollen, viz. *Ophrydeæ* and *Neottieæ*. It occurs in some species of *Thelymitra*, viz. *T. nuda*, *T. longifolia*, *T. pauciflora*, and in at least some forms of *Spiranthes australis*, Lindl.

2. By the falling of the pollen-masses as a whole from the clinandrium into the stigma. This is probably not rare, but I have met with records of but few examples. In a flower of *Phaius maculatus*, Blume, I recently received I found that by shaking, the pollinia had entirely slipped from the clinandrium

upon the stigma, to which they were adherent. In *Chiloglottis diphylla*, Fitzgerald states that the plant is adapted for insect-fertilization; but should this fail, the lip in withering is drawn up to meet the column, the calli attach themselves to the pollinia and extract them from the anther-cap, eventually rubbing them against the stigma. To this class must also belong *Arundina speciosa*, Blume, concerning which see H. O. Forbes in Journ. Linn. Soc., Bot. xxi. p. 543.

3. By falling forward of the pollinia, from the clinandrium or the anther-cap, the caudicle and gland remaining attached to the column. *Ophrys apifera*, Linn., is a well-known instance of this class, to which belong also *Œceoclades maculata*, the *Trichopilia fragrans* mentioned above, and the *Eria* described by Forbes in the paper just cited. In *Spathoglottis Paulinæ*, Fitzg., the pollinia slip forward, remaining attached by their apex, and curve round into the stigma.

4. By flooding of the stigma. The pollen-masses remain in the anther-cap, or on the clinandrium, while the stigma exudes so great a quantity of stigmatic fluid that it eventually reaches the edge of the pollinia, which immediately emit pollen-tubes. This seems to be the commonest method of self-fertilization. In some cases it is facilitated by suppression of the rostellum, as in *Cephalanthera pallens*, Rich., *Epipactis viridiflora*, Reichb. f., and the Australian form of *Spiranthes australis*, and one form of *Phaius Blumei*, Lindl. Without suppression of the rostellum it is recorded in the case of *Spathoglottis plicata*, Blume, *Phaius Blumei*, Lindl., *Eria albido-tomentosa*, a species of *Chrysoglossum*, and species of *Schomburgkia*, *Epidendrum*, and *Cattleya*, recorded without specific names by Crüger. Also in *Thelymitra longifolia*, R. Br., and *T. circumsepta*, Fitzg., both species of *Calochilus*, *Orthoceras stricta*, R. Br., and *Goodyera procera*, Lindl.

I would point out, in conclusion, that among the Orchids which often fertilize themselves will be found some of the species having the widest distribution in the Order, e. g. *Spathoglottis plicata*, *Spiranthes australis*, *Œceoclades maculata*.

DESCRIPTION OF PLATE XVI.

Fig. 1. *Trichopilia fragrans*, a cleistogamous flower; nat. size.

2. Upper part of column, much enlarged, showing the anther (A) slipping out of the clinandrium (Cl) into the stigma (*s*). *a* is the stelidium.

3. The same, viewed from the side.

Fig. 4. The same, in section. R. Rostellum; P. Pollinia.
5. The same at a later stage, the pollinia having become recurved into the stigma.
6. A later stage. The stelidia have curved over so as to overlap and press the pollinia into the stigma.
7. The same, side view.
8. The same stage, in section. *Gl.* Disc of pollinia.
9. Later stage. The pollen is now entirely plunged in the stigma and is almost absorbed.
10. Flower of *Œceoclades maculata*, Lindl., from the side; nat. size.
11. The same, with the petals and sepals removed; enlarged.
12. Column, showing the pollinia falling forward.
13. Front view of column, with the pollinia still hanging from the clinandrium by the disc, but in contact with the stigma.
14. Pollinia, enlarged.

On the Fertilization of *Cattleya labiata*, var. *Mossiæ*, Lindl.

By Harry James Veitch, F.L.S.

[Read 2nd February, 1888.]

Ever since Darwin conclusively showed how the pollinia of certain orchids were conveyed to the stigmatic surface by insect agency, the subject of orchid-fertilization has been of special and even growing interest, not only to science through its further elucidation by the discovery of many new and interesting facts, but also to horticulture as serving to explain, at least in part, how it is that so many anomalous forms having the appearance of hybrids have made their way into European gardens. But while the observations of Darwin and those who followed him in the same track have been directed chiefly to the simple act of pollination by insect agency, the investigation of the process that follows appears to have received but a limited amount of attention. With the view, therefore, of adding, if possible, somewhat to the small stock of information already possessed, and also of deducing therefrom some practical results that may help to guide the operations of the hybridist, I and my assistant, with the aid of an able draughtsman, were induced to undertake the series of observations I am now about to bring under the Society's notice. Our purpose was to note the progress of the pollen-tubes during their course through the conducting-tissues of the column into the ovary; to detect, if possible, the act of fertilization of the ovules, and to determine the time that elapses between pollination and that event; and, finally, to trace the development of the ovules after fertilization into perfect seeds.

Before giving a *résumé* of our observations, it is necessary to state that we worked under the serious disadvantage of being confined, for such work, to a low microscopic power; that, with the exception of a little glycerine, we used no chemical reagents in preparing materials for examination; and therefore very many details of the minute structure of the parts examined are necessarily omitted. It is also necessary to premise that these observations were undertaken and made before we became aware of the fact that the subject had been partially investigated many years ago by Dr. Hildebrand in the Botanic Garden at Bonn, the results of whose observations were published in Mohl and Schlechtendal's 'Botanische Zeitung' for October 30 and November 6, 1863. Dr. Hildebrand there tells us that, incited by Darwin's most interesting researches, he was induced, during the winter and spring months of 1863, to undertake a series of observations on some cultivated and also on some native orchids, with the object of ascertaining the time that elapses between the pollination of the flower and the fertilization of the ovule, an investigation that appeared to him to be pregnant with unexpected results, seeing that the sexual apparatus of orchids differs so greatly from that of the great majority of other Phanerogams. For the results of these investigations I must refer to the memoirs quoted. Much of the ground, therefore, having been previously travelled over by Dr. Hildebrand, I am afraid that the simple facts I am about to bring before the Society have not altogether the merit of novelty to recommend them; yet they may prove to be of *some* interest, and serve to revive the subject of the fertilization of orchids, which still offers a wide field for investigation.

The subject selected for our object was the well-known *Cattleya labiata*, var. *Mossiæ*, Lindl., because we could command a good many plants for investigation, and because also in this *Cattleya* the column and its parts are among the largest to be found in the Orchideæ; we hoped that the probability of our being able to prosecute our search with some chance of obtaining results would thence be the greater. The chief characteristics of the column of a *Cattleya* of the *labiata* group are sufficiently familiar to most botanists. The column of one of the members of the group, apparently of the same that forms our present subject, is well represented in Darwin's 'Fertilization of Orchids' at p. 161, where also some structural details are given. In the series of drawings made for illustration, fig. 1 represents the front view of the column and ovary of *Cattleya labiata*, var. *Mossiæ*, two thirds natural size, a few days after the expansion of the flower. From the apex or top of the pollinary apparatus to the base of the ovary it is about 3 inches long; although shown upright in the figure, it slightly arches forward from below the stigma to the apex, the part so bent is thence parallel with the labellum, which is, in fact, appressed to it, and enfolds it with its side lobes, a circumstance that immensely facilitates the pollination of the stigma by insect agency. The stigmatic cavity is separated from the anther by a tongue-shaped rostellum; the stigmatic surface is coated with a thick layer of transparent viscid matter which holds the pollinia when applied to it with extraordinary tenacity. The pollinia are four in number, each pollinium, or pollen-mass as we are more accustomed to call it, is a waxy flattened disk, neither strictly oval nor strictly circular, but something between the two, or nearly the shape of an artist's palette, and is furnished with a semitransparent ribbon-like caudicle, which is also covered with numerous pollen-grains. The ovary is cylindric, and is traversed longitudinally by three equidistant sunk lines. Fig. 2 represents a longitudinal section of the column and ovary, one fourth larger than natural size, in which the positions of the anther, rostellum, and stigma are shown by the letters P, A, and S respectively; there is a duct or canal leading from the stigma to the ovary, down which the pollen-tubes pass. This canal in transverse section has the form of a W-shaped curve extending through the central part of the column where it is thickest, as shown in fig. 4; it is filled throughout with con-

Fig. 1.

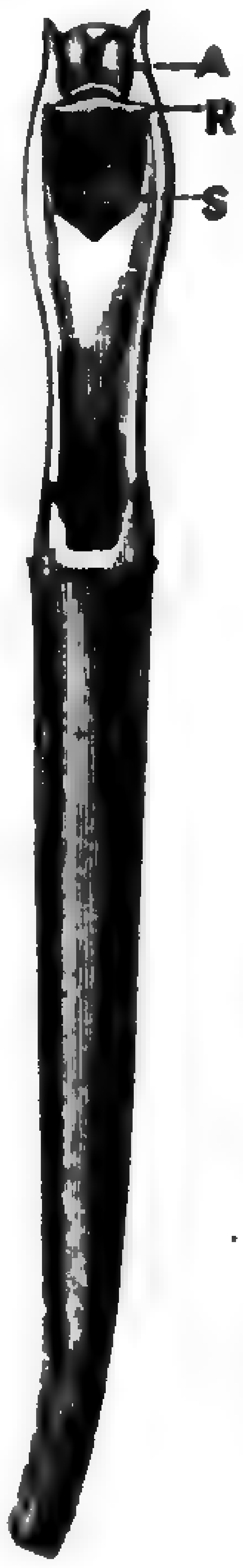
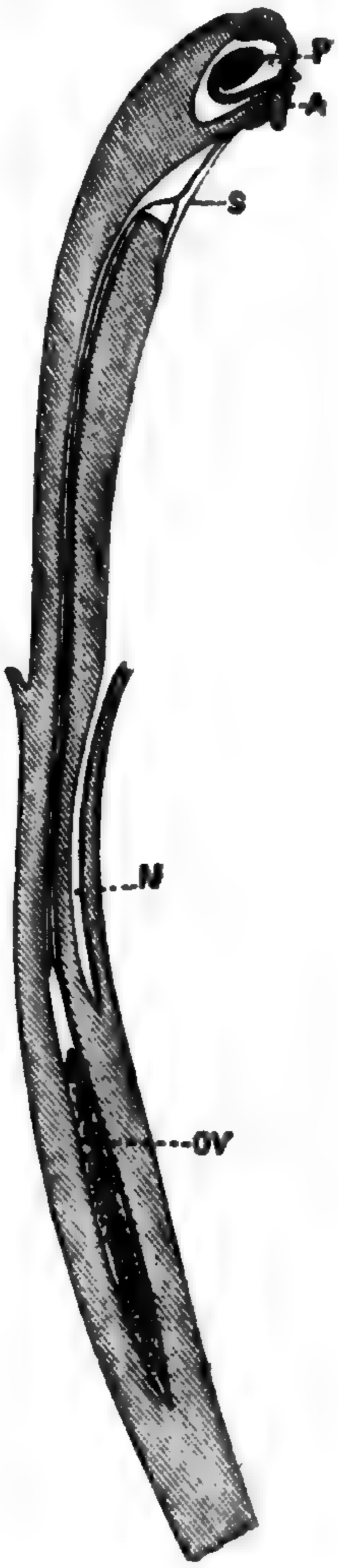


Fig. 2.



ducting-tissue which is of a very loose consistency, and formed of greatly elongated cells generally overlapping at their ends. The narrow slit at N (fig. 2) shows the nectary that penetrates into the ovary, and in which honey is freely secreted; OV is the immature ovary, of which, for the purpose of showing the parts more distinctly, an enlarged transverse section is given in fig. 3, where it is plainly shown to consist of three divisions or lobes, from each of which, where they approach at the centre, springs a placenta. Each placenta at this early stage consists of two thickened plates with their edges turned towards each other, and almost meeting, and thence almost enclosing a quadrangular space; the rudimentary ovules, or rather the papillæ that are subsequently developed into ovules, are placed along the projecting angles of these plates. We shall see that this position of parts of the ovary is considerably modified as the process of fertilization goes on. Fig. 4 shows a similar enlargement of the column in transverse section. Athough only eight times enlarged, it indicates sufficiently the parenchymatous tissue of the column and the position of the fibro-vascular bundles.

Fig. 3.

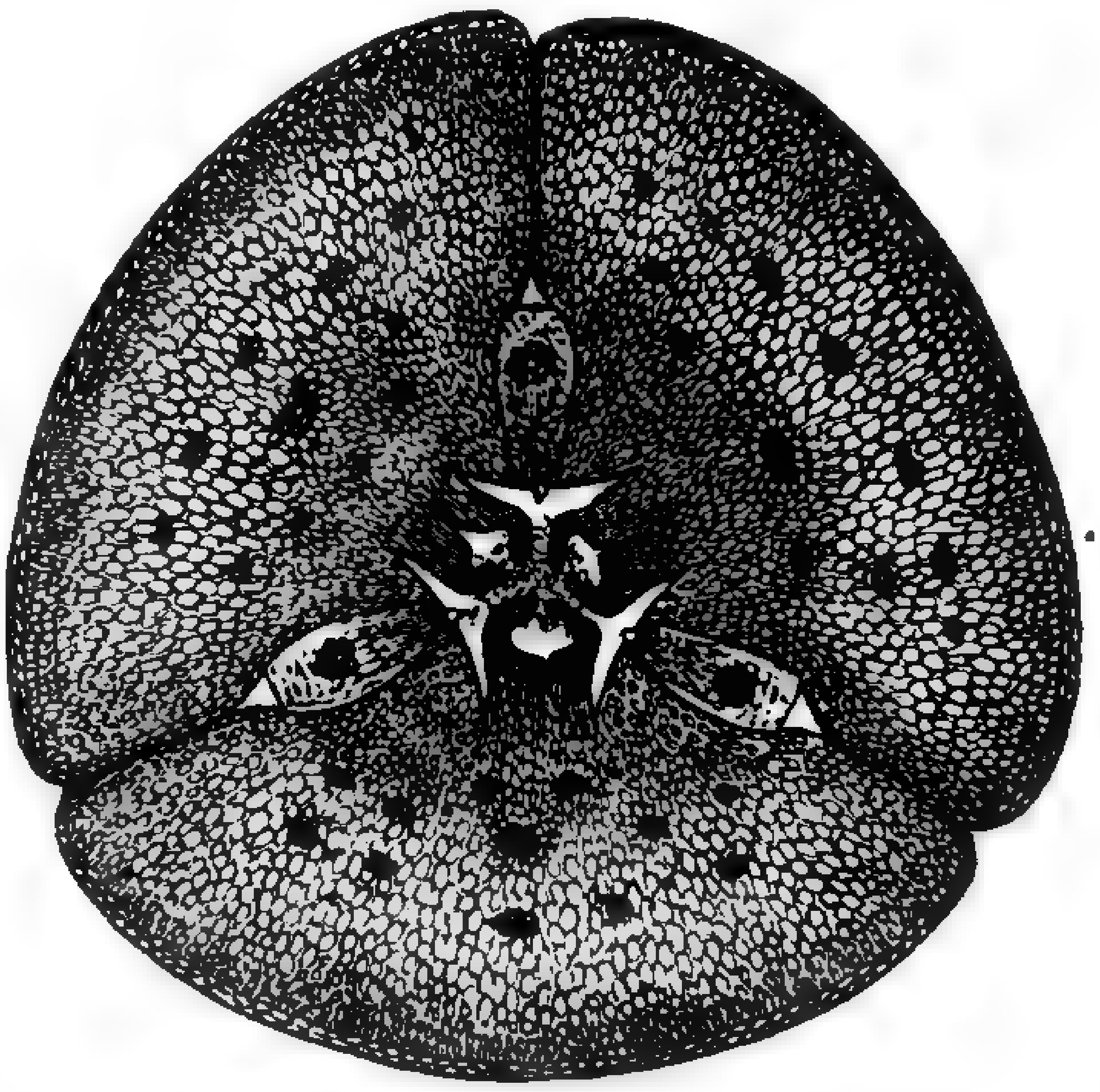
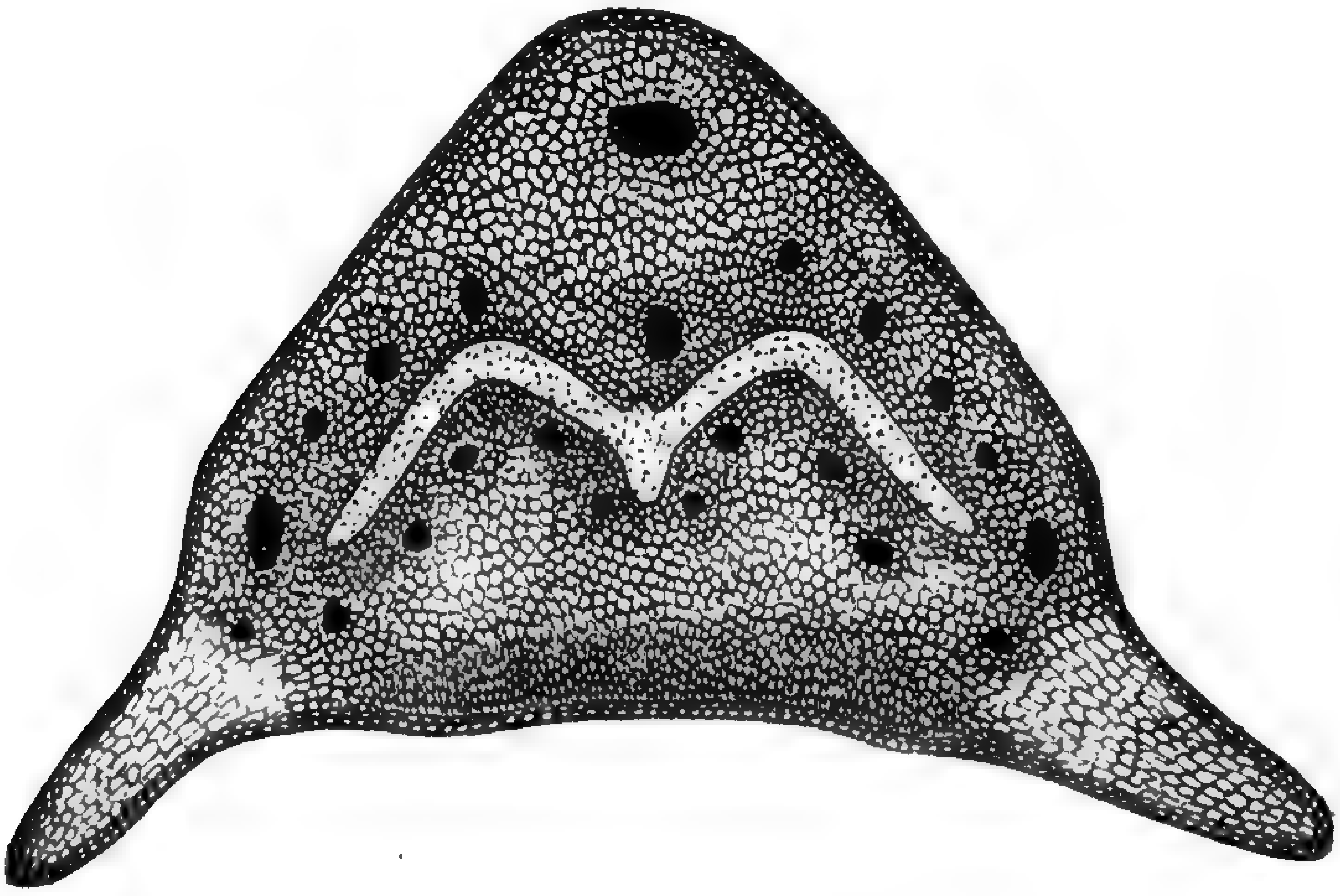
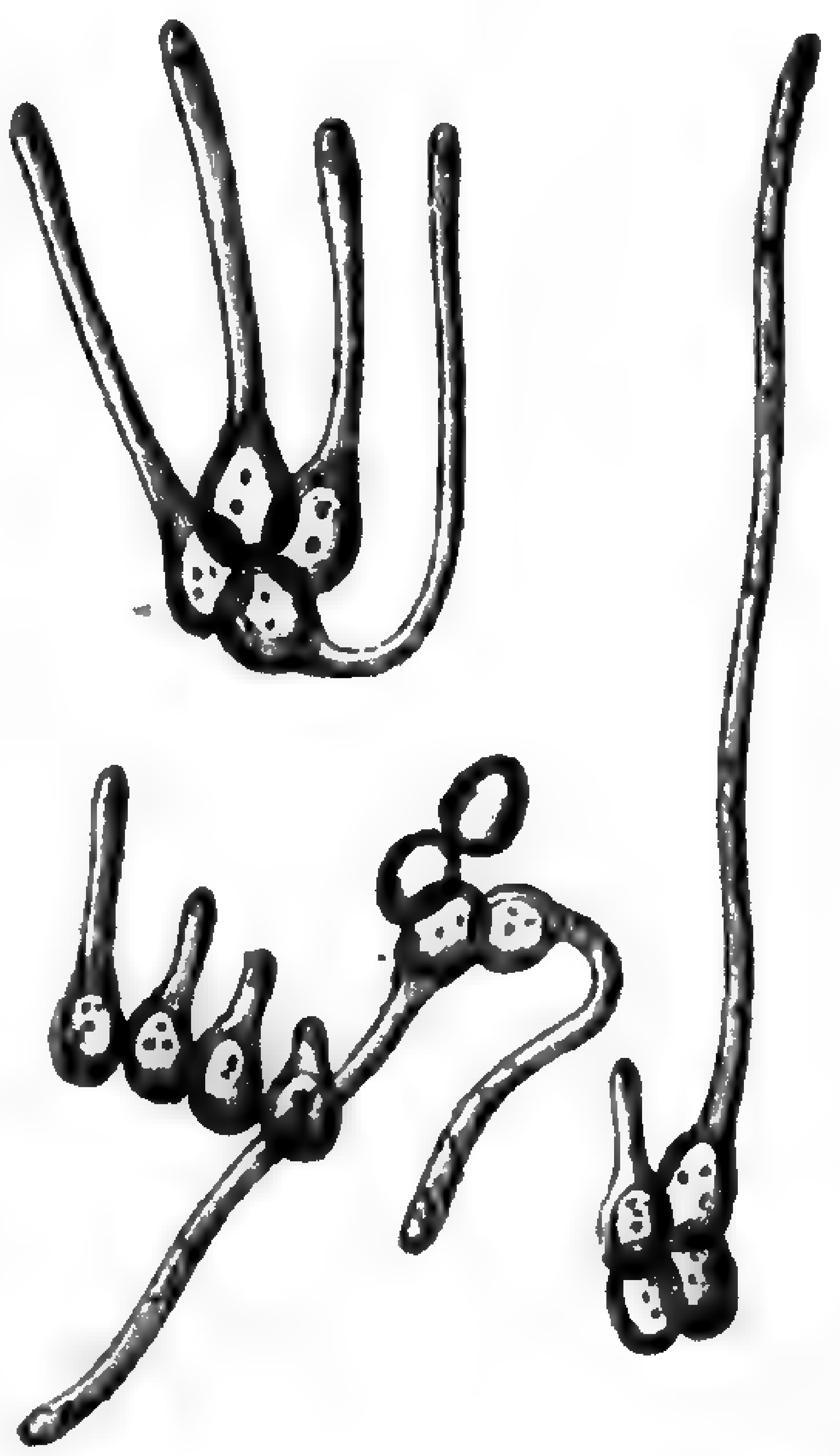


Fig. 4.



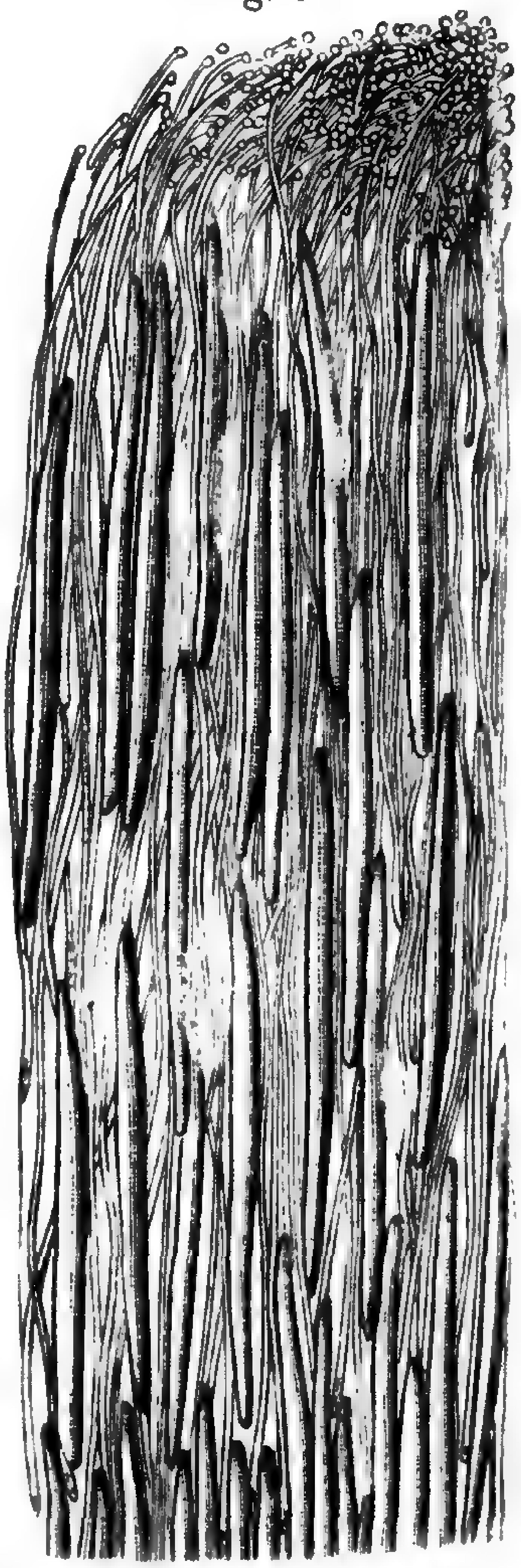
We are now in a position to trace the process of fertilization from the time of pollination to the impregnation of the ovules. On the 1st of June, 1885, forty-five flowers of plants of the same age of *Cattleya labiata*, var. *Mossiæ*, were selected for pollination: the flowers were divided into three equal sets of fifteen each, of which one set was fertilized with their own pollen; a second set with the pollen of different flowers but of the same variety; the third set was fertilized with the pollen of flowers of a different species (*Lælia purpurata*, Lindl.), the whole of the pollinia being applied in every case. The object of so varying the circumstances was to ascertain whether the fertilization of the ovules and subsequent ripening of the seed would be in any way differently influenced or affected thereby. We shall see in the sequel that no material differences were observable, or at least, when any were noticed, they were of too trivial a nature to be taken into account. At the time the operation was performed the weather was fine and bright, and continued so for several days afterwards. Two days afterwards the flowers were examined, and one from each group was cut. The floral segments had already become flaccid, and showed signs of rapidly withering. Under the usual cultural treatment, the flowers of a *Cattleya* of the *labiata* group retain their freshness after expansion for upwards of three weeks, and even a month in cloudy weather; hence the effect of pollination on the floral segments is here made perceptible within a few hours. The pollinia in each case were found to be in course of disintegration, forming, with the viscid secretion from the stigma, a gelatinous mass that quite filled up the stigmatic cavity. On examination under the microscope, it was found in all three cases that the pollinia were breaking up into groups, generally of four granules, from some of which short tubes had already protruded; in the case, however, of the flower fertilized with the pollen of *Lælia purpurata* only a few such groups could be detected, and from these the tubes had but just started. In fig. 5 four of these groups of granules, with their tubes, are represented, as seen under the highest power at our disposal, that is, magnified 170 times.

Fig. 5.



Two days later we again examined a flower from each set. The columns were found to be slightly enlarged at and over the stigmatic chamber, and a change of colour, owing to their full exposure to the light, was perceptible in the epiderm. Nectar had freely exuded from the base of the column, and had spread itself over the ovary; the disintegration of the pollinia was seen to have advanced considerably, and pollen-tubes had pushed down into the canal to about a quarter of an inch below the stigmatic chamber. The flower fertilized with the *Lælia*-pollen was somewhat less advanced than the other two. An interval of four days was then allowed to elapse before a further examination was made. By that time the floral segments had become quite withered, and the change of colour in the epiderm of the column had become more manifest; at first, the ridge along the top was dull purple, but the sides were pale green. Transverse and longitudinal sections of the column and ovary showed that the tubes emitted from the pollen-granules had increased immensely in numbers, and the foremost of them could be traced as far as the base of the column. Fig. 6 represents roughly the state of affairs at this epoch; the pollen-tubes, as observed under a magnifying-power of about 75 diameters, are here seen passing downwards among the elongated cells of the conducting-tissue in vast numbers.

Fig. 6.



Four more days were again allowed to elapse before a further examination was made (June 9–12); the weather in the mean time having been clear and warm and the pollinated flowers having been fully exposed to direct sunlight, we expected to find that the process of fertilization had considerably advanced. The columns had now become much harder in texture and green in colour; the gelatinous mass in the stigmatic chamber had parted with much of its viscidity, and was changing to a rusty-brown colour; the ovaries were perceptibly enlarged, and pollen-tubes could be clearly traced to their entrance, and a few of the more advanced had reached the apex of the placenta. The flowers in the three sets were now equally advanced; and from this time up to the conclusion of the observations scarcely any perceptible difference in condition was noticeable between them. From these and the previous observations, it now became very evident that the time which must elapse between the pollination of the flower and the impregnation of the ovules would be considerably longer than we anticipated.

Fig. 7.

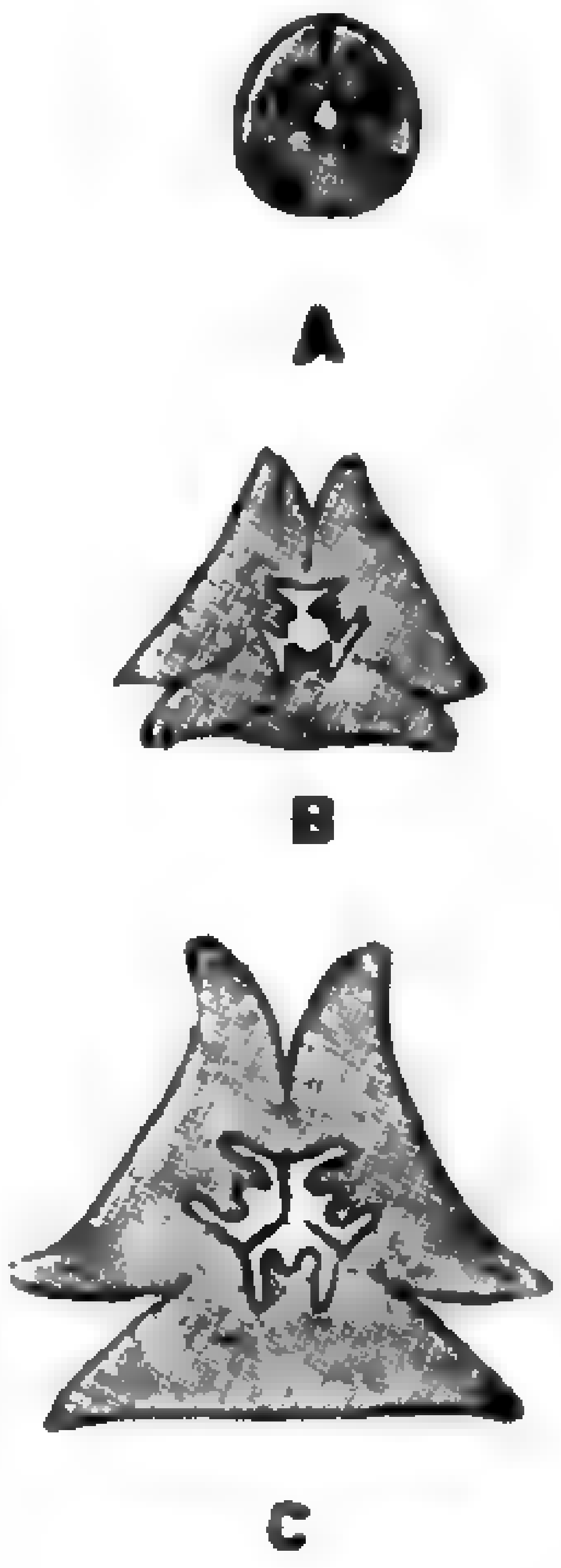
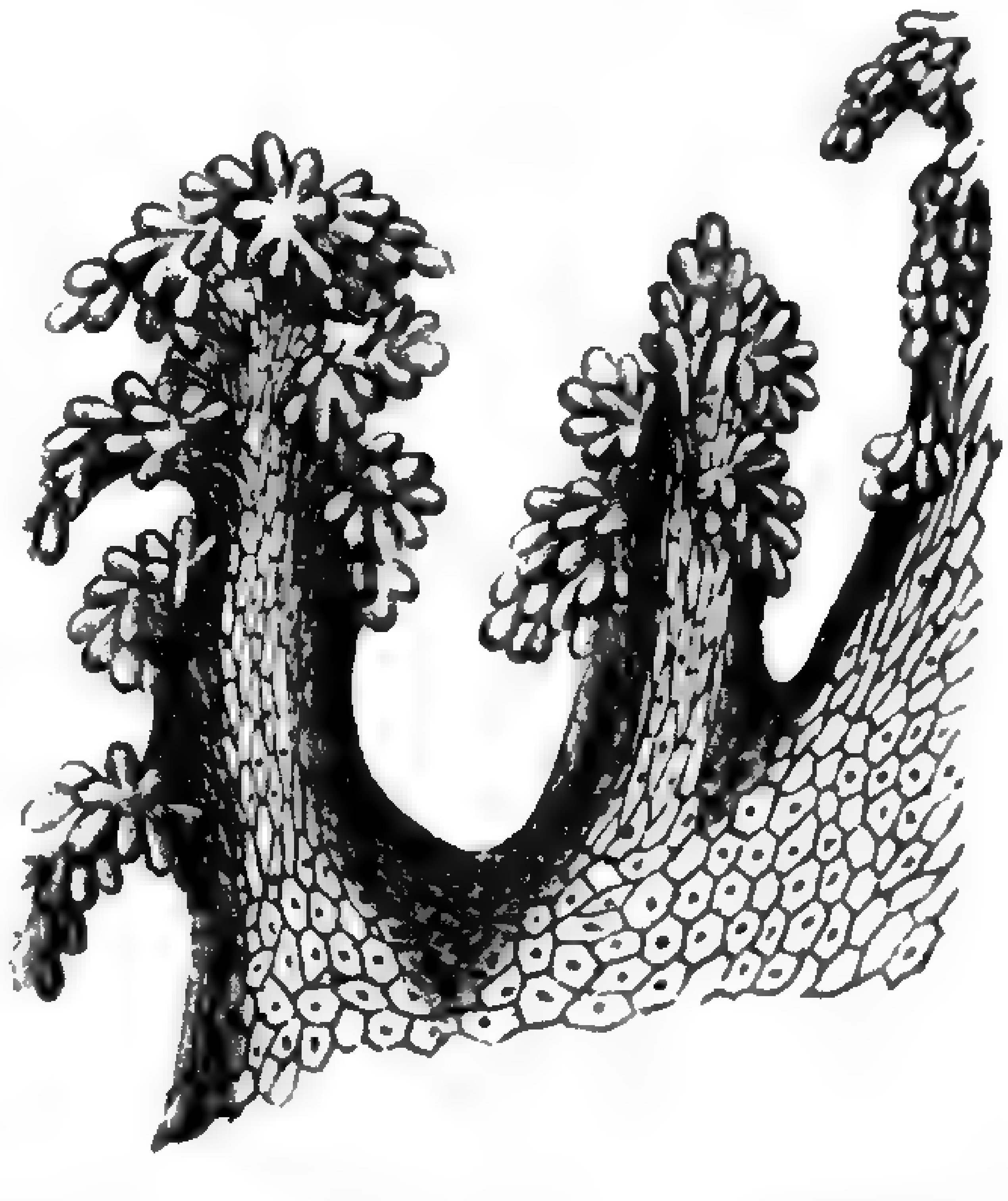


Fig. 8.



It is now time to turn to the ovary itself, and to take note of the changes that took place there from the time of pollination till the impregnation of the ovules. The very rudimentary state of these at the epoch of the expansion of the flowers has been already mentioned. Fig. 7 shows transverse sections, natural size, in three different and successive stages of development—(A) shortly after the expansion of the flower and before pollination: (B) a fortnight after pollination; the change of form that had taken place in this short interval is very striking; the outline had changed from circular to triangular; the simple sunk lines of the earlier stage had widened into wedge-shaped clefts, dividing the whole into three well-marked carpellary lobes; each lobe has attained an almost triangular form by the enlargement of the placenta, and by the thickening of the walls of the ovary itself: (C) shows the further development about a month after pollination; the placenta and rudimentary ovules had then began to assume a more definite form, although no signs of impregnation of the latter could be detected. On the day the last-mentioned section was made the pollen-tubes were found to have entered the ovary, and were pushing downwards along the sides of the placentas among the ovules. The condition of the ovules themselves at the same date is represented in fig. 8, where an enlarged view of a minute section is given; it is there shown that they are grouped in clusters of no very definite form and outline; each ovule has the appearance of a single cell of ovoid form, but so minute are they at this stage, that no differentiation of parts could be made out under the low power to which we were restricted, although a faint reticulation was observable in some of the most advanced; but this may have been an optical effect. It was, however, evident that the actual impregnation of the ovules by the pollen-tubes, which we were anxious to detect, was yet remote, or at least it was apparent that that event would not immediately occur. In fact, we were up to this time simply groping our way towards trying to ascertain what we hoped would prove to be a most interesting scientific fact, but with the road to which we were very imperfectly acquainted indeed.

Our next examination was made fifty-five days after pollination; but, to our surprise, although the pollen-tubes had penetrated the ovary in countless numbers, and had completely choked up the canal leading from the stigmatic chamber to it, so that they had there taken the form of a bundle of fibres, minute as are the individuals composing it, and could be pulled away bodily in a coherent string, no actual impregnation of the ovules could be detected; the tubes lay along the sides of the placentas and among the ovules, and had reached as far as the bottom of the ovary. Moreover, all this while, and for some weeks afterwards, the summer weather was, for our climate, very favourable for the development of the impregnated flowers, the number of bright clear days being rather above the average. We waited 17 days longer before making a further examination; we then found that the ovules were not only enlarged, but were also undergoing a change in form—a fact that induced us to believe that the long sought-for event was at hand, and we accordingly made a further examination three days later, but no perceptible advance could be detected. We therefore desisted from further trial for another fortnight, that is till 90 days after pollination, when, at length we were able to understand with tolerable certainty the process by which the impregnation of the ovules is effected, and to get an idea of the space of time required for its accomplishment.

This will be best understood by reference to the diagrams. In fig. 9 are represented, two thirds natural size, two transverse sections of the ovary—D 55 days and E 72 days after the pollination of the flower; in fig. 10 a transverse section 90 days after pollination, also two thirds natural size: these, with the drawings in fig. 7, form a series. The development of the ovules themselves is represented at five different stages in fig. 12, and four later in fig. 13, all greatly enlarged, thus:—

Fig. 9.

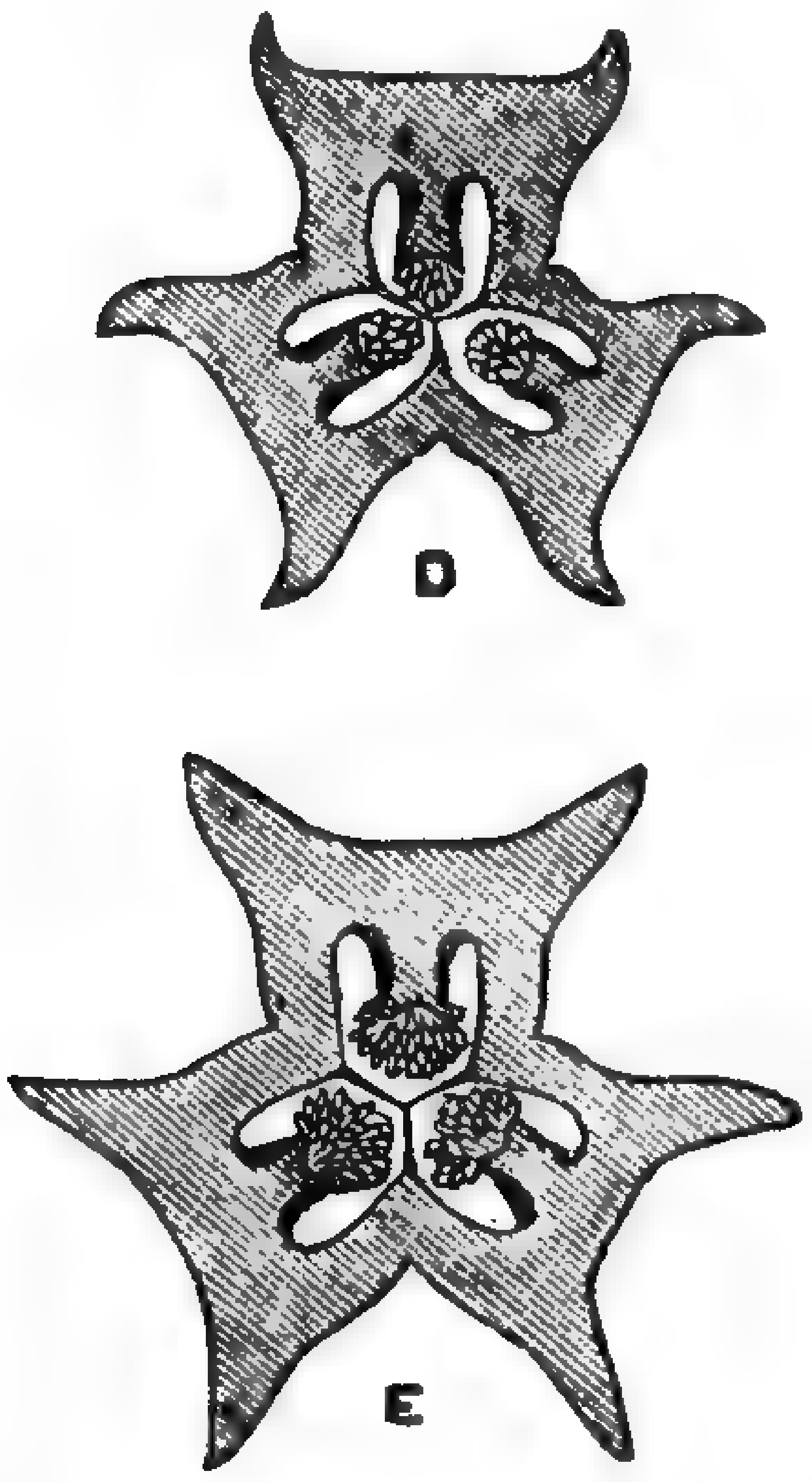
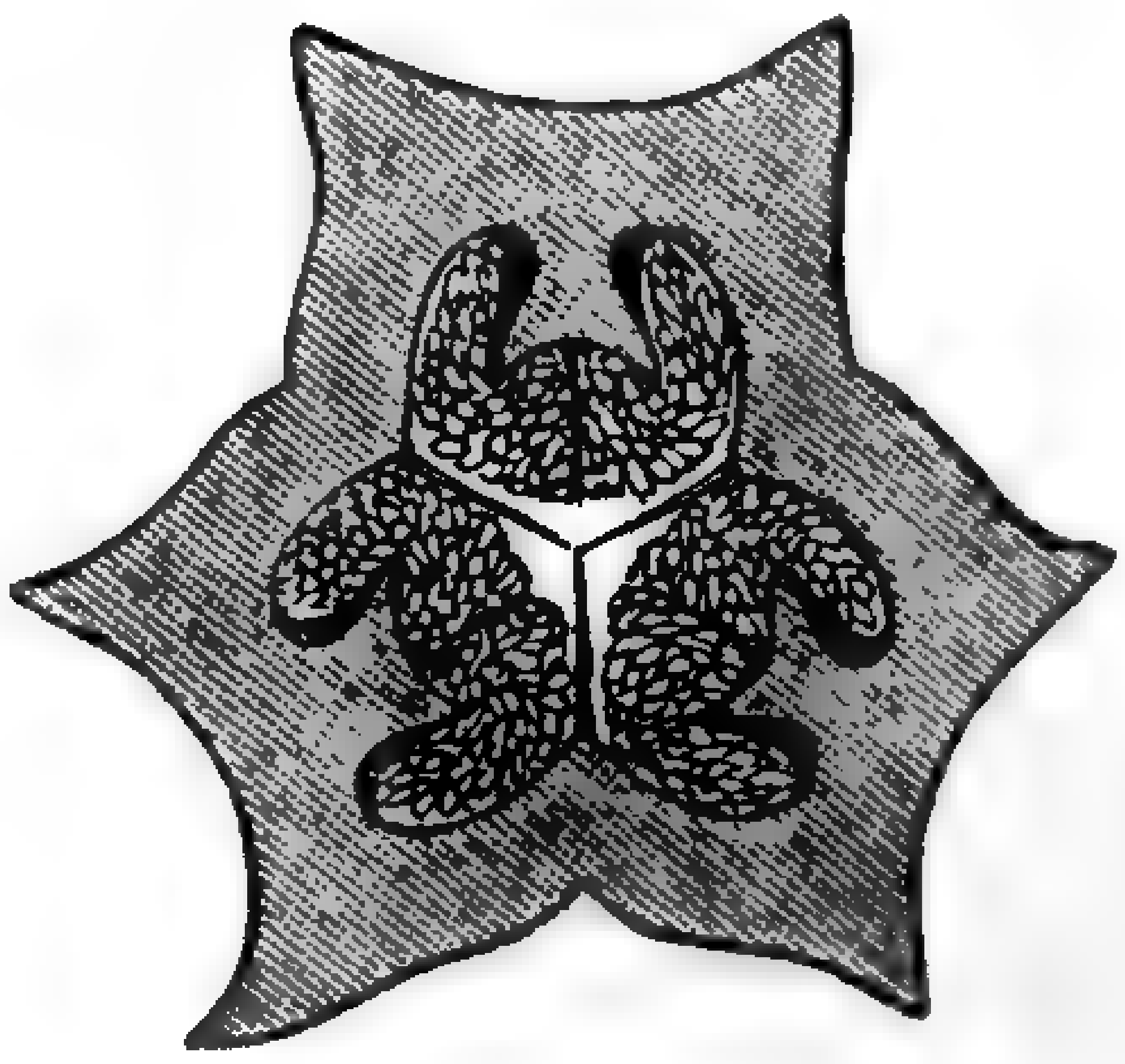
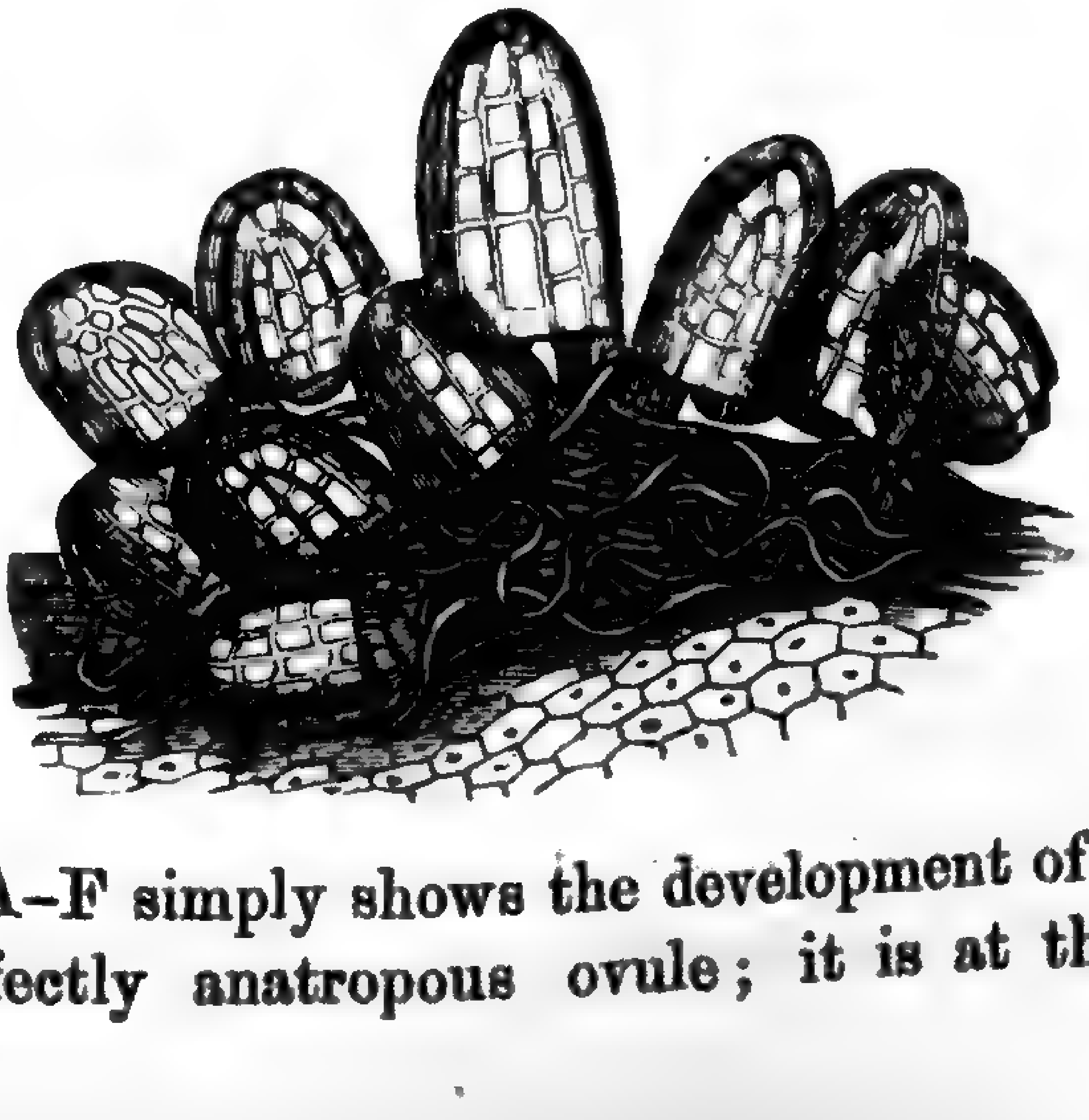


Fig. 10.



A, the ovule rudiment before pollination.
B, " " 30 days after the pollination of the flower.
C, " " 55 " " "
D, " " 66 " " "
E, " " 72 " " "
F, " " 75 " " "
G, " " 90 " " "
H, " " 120 " " "
I, " " 150 " " "

Fig. 11.



The series A–F simply shows the development of the rudiment nto the perfectly anatropous ovule; it is at this stage that impregnation takes place. That the pollen-tubes then come into contact with the true apex of the ovules is certain, but this was all we could detect. In no case could we find that the tubes actually penetrated the ovules; nor could we detect any embryo-sac or other differentiation of parts in the ovule itself under the low power we were constrained to use, and owing to the minuteness of the ovules even at this stage; but our failure to discover these parts by no means excludes the supposition of their existence, either in the form in which they occur in other monocotyledonous plants, or in some modification of that form.

Fig. 12.

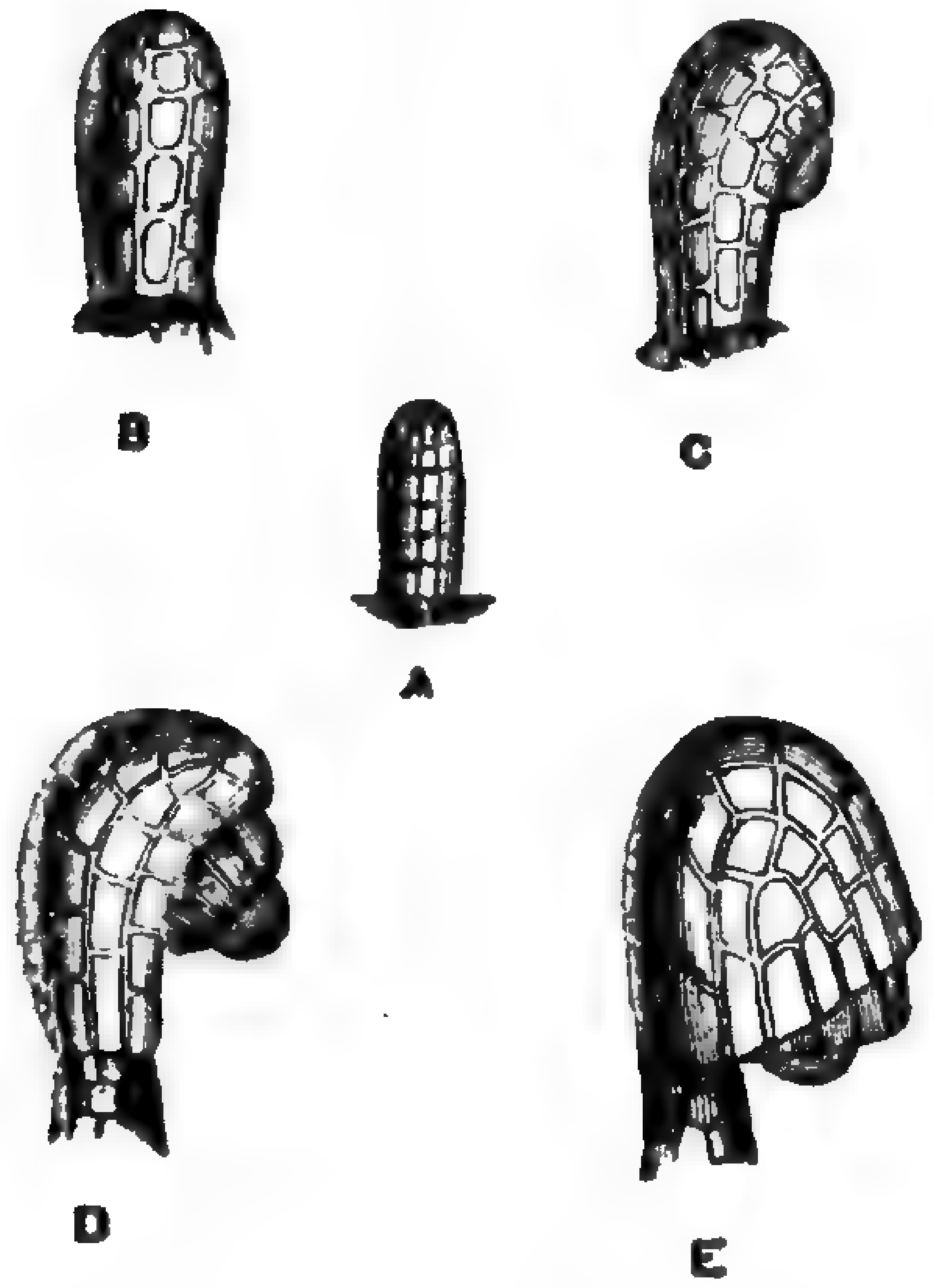
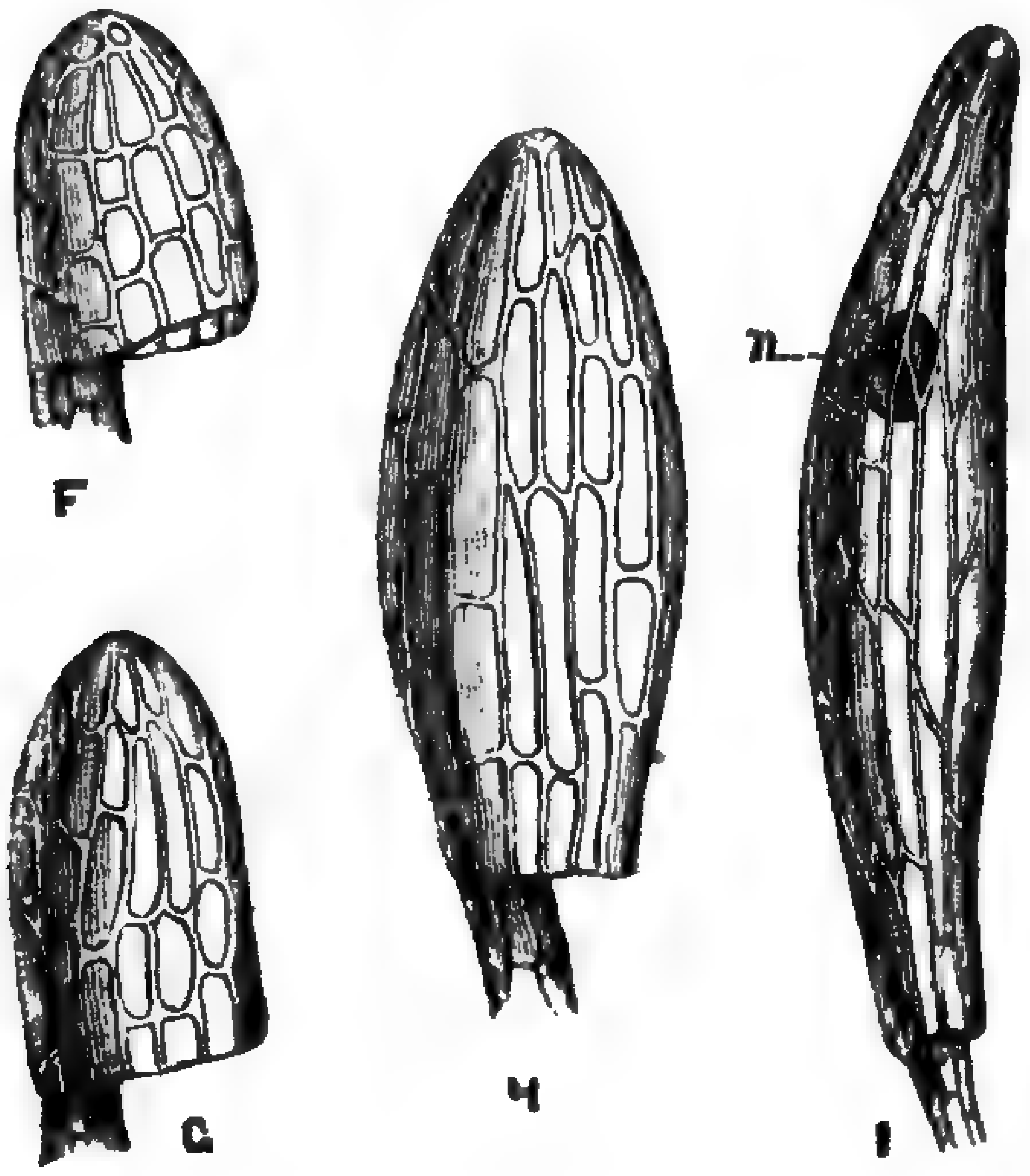
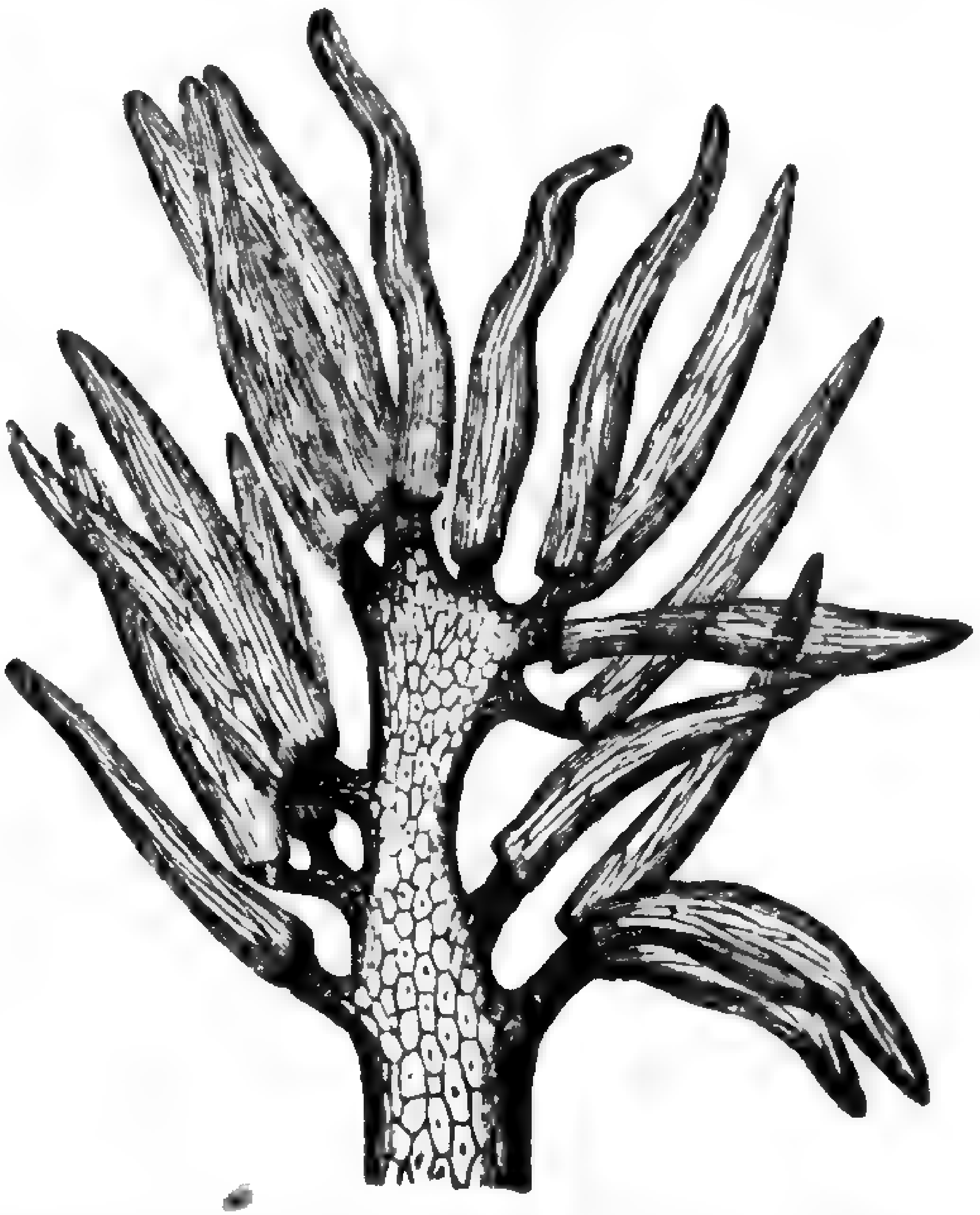


Fig. 13.



But to return to observed facts. The pollen-tubes push down into the ovary in countless numbers, and make their way along the placentas and among the protuberances of it that bear the groups of ovules in the manner shown in fig. 11. The form of the ovule at this stage may be regarded as nearly cylindric, being slightly contracted at the apex. It will be noticed that this form differs considerably from the elongated spindle-shaped mature seed; and having still some materials left, we were desirous of observing one or two intermediate stages of the development of the former into the latter; we therefore cut one of the remaining capsules about four months after the pollination of the flower, and found the supposed impregnated ovules had attained the form represented by H in fig. 13. As this showed but a very slow development, we waited another month before examining another capsule; by this time the ovules, or seeds as we should perhaps now call them, had become elongated in one direction and contracted in the other, as shown by I in fig. 13. A group of ovules at this stage, magnified 45 times, is shown in fig. 14. It was now clear that the impregnated ovules had attained their mature form and size, although, from our experience in hybridizing orchids, we were sure the seed would not be ripe for some months to come. As the days at this period of our investigation were getting short and cold, and artificial heat alone had to be depended on to maintain the plants in health, we desisted from further examination; and the few remaining capsules were left on the plants to mature their seeds or to fall, as the case might be, the latter being quite a common occurrence under the artificial conditions tropical orchids are cultivated in this country. When I say fall, the expression is not literally correct; the peduncle shrivels and withers, and the capsule dehisces before the contained seeds are mature, a cause due probably more to the murky condition of the atmosphere of London during the winter months than to any other I can suggest. It happened in the present instance that two of the remaining capsules failed in this way to mature their seed, and split early in March; the contents were examined, but showed nothing more than the shrivelling that would naturally be expected under the circumstances. The remaining two matured their seed and dehisced towards the end of May, or about twelve months after pollination. A number of the seeds were examined with the aid of the microscope; about one half were found to be plump; they may therefore be assumed to have been good; the other half consisted of mere dust and shrivelled ovules. The question at once suggested itself, Had these apparently abortive ovules ever been impregnated by the pollen-tubes? I think not; for on the same day the ovules were found in the condition represented in fig. 14, and

Fig. 14.



where numberless pollen-tubes were observed in the position there shown; in another section made from the same capsule no tubes could be detected, although the ovules had enlarged in the same way.

From the foregoing series of observations, we are enabled to deduce the following general statements :—

The impregnation of the ovules of *Cattleya labiata*, var. *Mossiæ*, under glass in the climate of London takes place from 75 to 90 days after the pollination of the flower, the length of time being doubtless influenced by the state of the weather during the interval, and especially by the amount of direct sunlight the plants receive; the more direct sunlight, the shorter the interval, and *vice versâ*.

A proportion of the ovules only are fertilized; but how great that proportion is it is not possible to determine with certainty; it is never probably much less than one half; it probably varies from a little less to a little more than one half. It is certain also that of the seeds which are apparently mature and good, a greater or less proportion of them failed to germinate under artificial conditions.

It takes about twelve months, under the same conditions, to effect the maturation of the capsules; it being highly probable that during the winter months, when the temperature in which the plants are kept is comparatively low, and the amount of direct sunlight and sun-heat is at the minimum, there is a cessation of growth which is renewed as the summer months are approached.

In bringing my notes to a close, permit me to say that I have simply endeavoured to bring before the Society at least some of the phenomena that occur in the fertilization of orchids, which, so far as I am aware, have not previously been observed; and if in so doing I have added ever so little to our knowledge of the wonderful processes by which Nature effects the reproduction of these remarkable plants, I shall feel amply repaid for the time given to the investigation.

On PANICUM SUPERVACUUM, sp. nova.

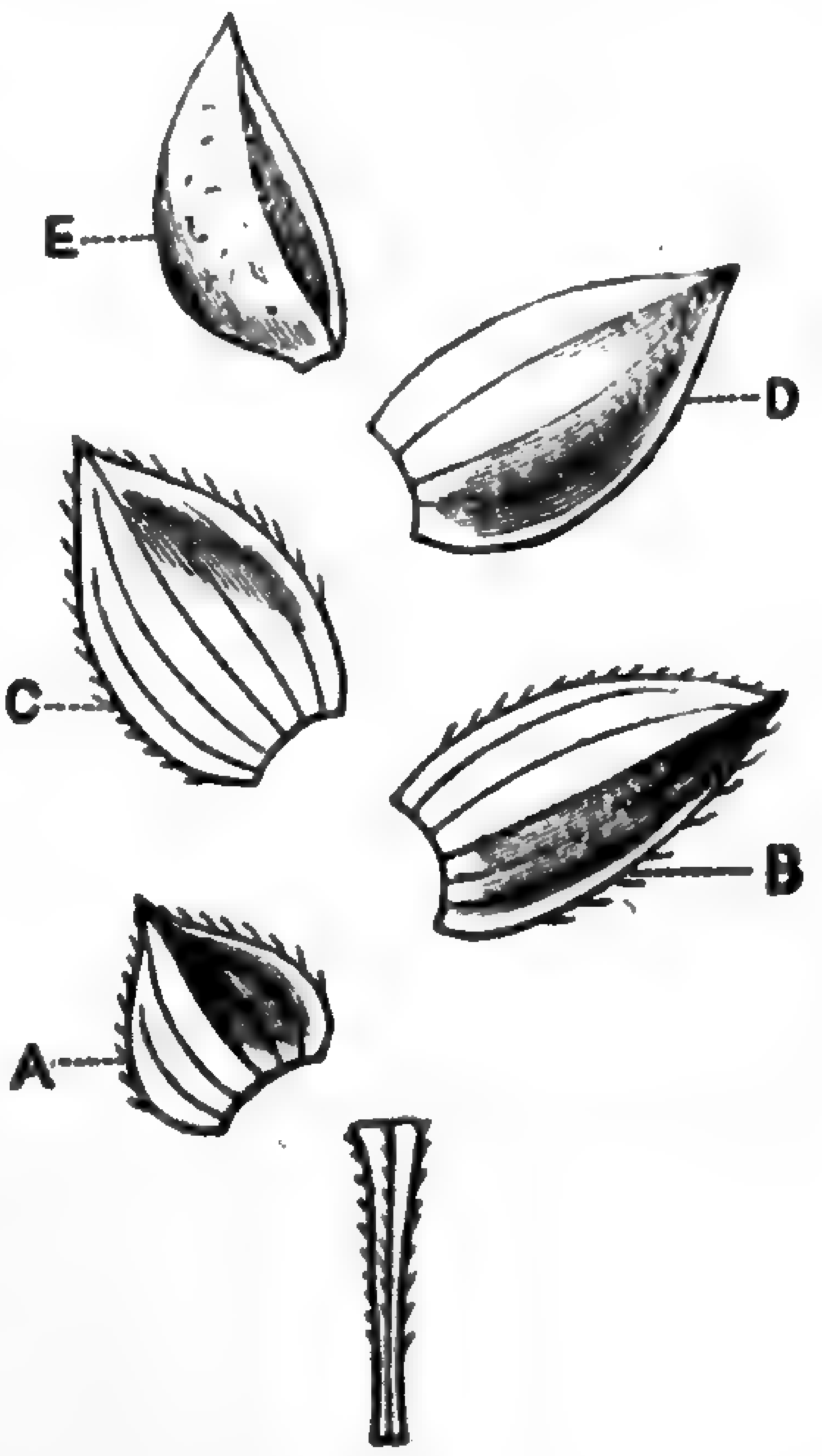
By C. B. CLARKE, F.L.S.

[Read 1st December, 1887.]

Panicum supervacuum (*i. e.* redundant) differs from all other Panicums (and their allies) by having *constantly* an extra flower interposed between the male and female flowers in each spikelet.

In the annexed figure, representing one spikelet dissected out, A is the lower glume, B the upper glume, C the lower flower (always reduced to an empty lower pale in the present species so far as seen), D the redundant flower, E the perfect closed flower, which is hardened brown, showing, under a low magnification, obscure transverse wavy marks, as is common in *Panicum*. The hardening of the fertile flower in *Panicum* is caused by a corrugated thickening of the walls of the cells. As is so common in Panicums of the *P. prostratum* group, the glumes A, B, and the lower flower C are pilose, while the fertile flower E is glabrous.

The intermediate flower D is intermediate in character between the male C and the fertile E. Sometimes it has an upper pale and a small rudiment (possibly of a pistil); and in these cases it is partially hardened, quite glabrous, and shows the corrugated thickened cells and very obscure transverse wavy marks, as in the lower pale of the fertile flower. Sometimes it is empty, and then less thickened, and occasionally minutely pilose. The interposed flower is inserted in regular alternation; so that the fertile flower E comes over the lower glume A, instead of over B as in all other Panicums. The pedicel is articulated below the lower glume; and the species shows so far no tendency towards *Isachne*: it is a very common-looking *Panicum*, near *P. prostratum*, Lam., and *P. antidotale*, Retz., and, without dissection, might be actually sorted into the Kew bundle of *P. prostratum*, which comprises a considerable range of forms.



On my showing this species to Prof. Oliver, he called my attention to the cases of *P. rude*, Nees, and

P. cayennense, Lam., mentioned by Doell (in Mart. Flora Brasil., Gram. pp. 127, 128, *in nota*), in which species Doell has noticed an extra flower. In these cases, however, the redundant flower occurs only exceptionally, causing the spikelets to look "double." In *P. supervacuum* the spikelets are closed, not more turgid than those of *P. prostratum*. It may be suggested that *P. supervacuum* is a state of *P. prostratum*, Lam. (or one of the numerous closely allied species thereto), arising from cultivation or accident. To this I reply that no *Panicum* of this group is cultivated in India, so far as I know; and that I have collected *P. supervacuum* both in the Terai of Sikkim and near Moorshedabad. The uniformity of structure of the spikelets throughout these examples has caused me to treat it as a species, of which I append a technical description, using (as throughout this paper) the terminology of Kunth.

PANICUM SUPERVACUUM. Culmi 3–4 dm. longi, ramosi, vagantes. Folia 7 cm. longa, 8 mm. lata, basi truncata, in utraque facie pilosa; ligula ex annulo pilorum constans. Panicula 1 dm. longa, laxa; rami 4–5 cm. longi, distantes, lineares, parum divisi. Spiculæ 3 mm. longæ, irregulariter sparsæ, sæpe geminatæ (altera sessilis, altera pedicellata); pedicelli minute pilosi, sub glumis articulati. Glumæ (cum flore inferiore) pilosæ: inferior cum ⅓ parte superioris æquilonga. Flos imperfectus (1- vel 2-paleatus) supervacuus inter florem masculum et florem perfectum interpositus.—Species *P. prostrato*, Lam., similis.

Hab. Bengalia, *C. B. Clarke*, nn. 35103, 33585, 36932.

Supplementary Note on the Ferns of Northern India.

By C. B. CLARKE, F.L.S., and J. G. BAKER, F.L.S.

[Read 3rd November, 1887.]

J. G. BAKER has been looking through the miscellaneous collection of Ferns which C. B. Clarke has lately brought from Northern India, and selecting therefrom such specimens as he wishes to have pasted down in the Kew Herbarium. It has been the practice of J. G. Baker, in similarly picking over fern collections for

Kew, to publish a note of the new and critical plants; because, if no record is thus kept, when the selected specimens have been once sorted into their places in the Kew herbarium, it is practically impossible to collect them again.

We have therefore drawn up the present Note, which is in the form of a supplement to the paper of C. B. Clarke, "On the Ferns of Northern India," published in the 'Transactions' of this Society, series 2, Botany, vol. i. pp. 425-611.

The collection of C. B. Clarke included some ferns authenticated by H. Blanford; and among these some species lately printed in H. Blanford's 'Simla Cheilanthes': and there are a few miscellaneous observations noted by J. G. Baker referring to North-Indian Ferns, but not exactly suggested by the collection of C. B. Clarke.

1. **CYATHEA DECIPIENS**, *C. B. Clarke et Baker*; i. e. Hemitelia decipiens, *J. Scott in Trans. Linn. Soc.* vol. xxx. p. 33, t. 14; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 430.

Certissime *Cyathea*. In C. B. Clarke, nn. 44025, 38322, involucra (imo in sicco) spherica completa sunt. Hooker f. et T. Thomson, et G. Gammie e plantis cultivatis hanc plantam cum *C. spinulosa*, Wall., conjunxerunt.

2. **CYATHEA BRUNONIANA**, *C. B. Clarke et Baker*; i. e. Alsophila Brunoniana, *Wall.*; *Hook. Sp. Fil.* vol. i. p. 52 = Hemitelia Brunoniana, *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 430.

Involucra juniora sphærica completa.

3. **ALSOPHILA SIKKIMENSIS**, *C. B. Clarke et Baker*; fronde 2-pinnata 3-pinnatifida; pinnularum segmentis majusculis, anguste oblongis, conspicue crenato-serrulatis, venulis 2-fidis multisque 3-fidis, rhachidibus ferrugineo-bullatis neque hirtulis.

Non spinosa. Caudex visa 6-pedalis. Frondes 6–10-pedales; rhachis mollis a paleis adpressis brunneo-castaneis ligulato-linearibus (½ unciam longis) dense intecta. Pinnæ longæ 18–24 uncias, latæ 6 uncias, oblongæ, lateribus subparallelis. Pinnulæ longæ 4 uncias, latæ 1 unciam, teneræ: segmenta crenata interdum paullo pinnatifida. Sori 4–10 in unoque segmento, in 2 seriebus rectis dispositi: sori juniores, sphærici, virides, omnino nudi.

Sikkim; Rungbee, alt. 5500 ped., *C. B. Clarke* n. 36377.

4. **Dicksonia appendiculata**, *Wall. List*, 65, var. **Elwesii** (sp., *Hook. et Baker*, *Syn. Fil.* p. 54).

E serie exemplorum *D. Elwesii* a Levinge communicatorum, Beddome *D. Elwesii* pro var. glabra *D. appendiculæ* habet.

5. **Hymenophyllum flaccidum**, *Van den Bosch*; *Bedd. Ferns Brit. Ind.* t. 276.—H. denticulatum, *Sw.*, var. flaccidum, *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 438.

Khasia; Cheira, alt. 4300 ped., *C. B. Clarke* nn. 42796, 45773.

Exemplis copiosis comparatis, J. G. Baker hanc plantam pro specie (nec varietate) habet.

6. **Trichomanes bipunctatum**, *Poir.*; var. late alata, *Van den Bosch*, *Hymen. Suppl.* p. 54 (sp.).

Sikkim, *J. D. Hooker*, *Griffith*; Rungbee, alt. 5500 ped., *C. B. Clarke* n. 36386.

Hæc var. a *T. bipunctato*, Poir., typ. multum distat fronde sessili nec stipitato; charactere a C. B. Clarke in Trans. Linn. Soc. ser. 2, Bot. vol. i. p. 440, præterviso.

7. **Davallia membranulosa**, *Wall.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 442.

Darjeeling; alt. 6000 ped.—In Sikkim a Levinge etiam lecta.

8. **Davallia dareæformis**, *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 443.

Hoc loco plantæ duæ confusæ sunt; cf. C. B. Clarke in Journ. Linn. Soc., Bot. vol. xix. p. 291. H. C. Levinge has duas in uno genere in unica sectione collocat. In exemplis juvenilibus *Polypodii dareæformis*, Hook., ne vestigium ullum involucri discernere potuimus.

9. **Davallia pulchra**, *D. Don*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 444.

Var. **Delavayi** (sp., *Beddome*, *MS.*); tenuius divisa, fere quadripinnatifida, segmentis ultimis minimis oblongo-linearibus.

Khasia; alt. 5000–5600 ped., *C. B. Clarke* nn. 45473, 44251. Yunan, *Delavay*.

Varietas a cæteris exemplis orientalibus *D. pulchræ* multum recedens, var. *pseudo-cystopteris*, Kunze, potius referens, sed in hac segmenta ultima multo longiora sublanceolata.

10. DAVALLIA BULLATA, *Wall.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 445.

Var. CYPHOCHLAMYS; involucris late campanulaceis, lateribus fere liberis.

Khasia; Shillong, alt. 4000 ped., a C. B. Clarke et G. Mann lecta.

Varietas inter *D. bullatam* et *D. Griffithianam* quodammodo intermedia; squamæ rhizomatis interdum albidæ.

11. CHEILANTHES FARINOSA, *Kaulf.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 457.

Var. SUBDIMORPHA; frondibus triangularibus, stipitibus frondium sterilium brevissimis, fertilium elongatis.

Khasia; Shillong, alt. 5000 ped., *C. B. Clarke* n. 40529 &c.

Varietas inter *C. farinosam* et *C. argenteam* fere intermedia ex sententia Beddome.

Var. ANCEPS (sp., *Blanford* ! *Simla Cheilanthes*); stipitum squamis numerosis, castaneis, in margine pallidis; frondibus in lamina inferiore albo-farinosis.

Himalaya Occidentalis; alt. 4000 ped., *Blanford.* Khasia; alt. 5000 ped., frequens, *C. B. Clarke* n. 40528 &c.

Var. inter *C. farinosam* et *C. albo-marginatam* fere intermedia. —*C. grisea* (sp., Blanford ! Simla Cheilanthes), nobis, *C. farinosæ* forma minor videtur.

Var. TENERA; fronde tenera, parva, subtriangulari, parum farinosa.

Khasia; Khiri Flum., alt. 2500 ped., *C. B. Clarke* n. 45686.

12. CHEILANTHES ARGENTEA, *Kaulf.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 458.

Var. SULPHUREA, *Hook.*

Ab hac *C. farinosam*, var. *chrysophyllam*, Hook., distinguere nequimus. *C. argentea* et *C. albomarginata* quasi *C. farinosæ* formæ forsan habendæ sunt.

13. ONYCHIUM JAPONICUM, *Kunze*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 459.

Rhizoma semper longe repens, mediocre nec crassum, frondibus remotis; in var. *multisecta* rhizoma omnino idem.

14. **Pteris Grevilleana**, *Wall.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 466.

Adde syn. *P. quadriaurita* var. *digitata*, Baker in Trim. Journ. Bot. 1879, p. 40.

Adde habitat: Assam; Luckimpore, alt. 300 ped.; Garo Hills, alt. 1200 ped.

15. **Asplenium longissimum**, *Blume*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 478.

Adde habitat: a Garo Collibus usque ad Muneypoor, alt. 100–1000 ped., frequens.

16. **Asplenium longifolium**, *D. Don*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 478.

In exemplis, a H. Blanford communicatis, J. G. Baker paucos soros diplaziformes invenit.

17. **Asplenium drepanophyllum**, *Hook. et Baker*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 487.

Adde habitat: Panchmurree, *H. Blanford.*

18. **Asplenium Filix-fœmina**, *Bernh.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 491.

Adde Var. 8. Schimperi, sp., *Moug.*; *Fée, Gen. Filic. (Polypod.)*, p. 187; rhizomate horizontali elongato.

Simla, *H. Blanford.*

Exempla, a H. Blanford communicata, cum Abyssinicis omnino congruunt; H. Blanford autem exempla misit alia quorum rhizoma abbreviatum stipitibus contiguis.

19. **Asplenium sylvaticum**, *Presl*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 497.

Exempla ex unica grege lecta variant pinnis subintegris, pinnis plus minus pinnatifidis et pinnis pinnatis! *C. B. Clarke* n. 45594 &c. *A. acuminatum*, Wall., est idem. *A. speciosum*, Mett. (Hook. & Baker, Syn. Fil. p. 235), quoad majorem partem ex *A. acuminato*, Wall., constat: exempla autem pauca a Malaya paullum distant segmentis (sæpius brevibus) acutissimis, soris longissimis. *A. sylvaticum* quoad exempla australiora et Zeylanica recedit textura tenuiore et margine acutius serratula. E sententia Beddomei, *A. sylvaticum* (formæ Nilagiricæ Zeylanicæ) species est bona; *A. sylvaticum* (formæ Himalenses Khasianæ Burmannicæ) species est diversa cum *A. latifolio* fortasse olim conjungenda.

20. ASPLENIUM TORRENTIUM, *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 500, tab. 64 (fig. 2 excl.).

Simla, alt. 6000 ped., *H Blanford.*

Tab. 64. fig. 2 est *A. latifolium*, D. Don: error magna a Beddome detecta.

21. ASPLENIUM SIKKIMENSE, *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 500, est (fide Beddomei) *A. polypodioides*, Mett., var. *aspera*, sp. Blume.

22. ASPLENIUM MULTICAUDATUM, *Wall.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 502.

Forma *typica*: rhizomate horizontali subhypogæo elongato, fronde regulariter secta, soris minusculis.—Forma præsertim in Himalaya lecta.

Var. TRISTIS, *C. B. Clarke, l. c.*; rhizomate horizontali hypogæo elongato; fronde parva aut magna laxe irregulariter secta, soris (quam in forma typica) majoribus.—Var. in Khasia copiosa.

Var. CAUDICEA, *Baker et C. B. Clarke*; rhizomate suberecto stipitibus cæspitosis; fronde ut in var. *tristi* secta; soris minusculis.

Khasi et Garo Colles, alt. 2000–5000 ped., frequens. E sententia Beddomei hæc varietas est *A. umbrosum* var. *australis*.

23. ALLANTODIA JAVANICA, *Bedd.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 505.

In Hook. et Bauer, Gen. Fil. t. 120 A (ut in exemplis aliis) involucrum exacte allantodioideum fere inferum (cyatheoideum) depictum est: in exemplis aliis C. B. Clarke n. 35390, involucrum superum ab altero (exteriore) latere dehiscens omnino Asplenii evadit. In exemplo *Asplenii unilateralis*, Lam., in h. Beddome propr. conservato, involucrum inferum omnino ut Allantodiæ typicæ, Hook. et Bauer, Gen. Fil. t. 120 A, exstat. In sectione *Pseudallantodia Asplenii* (C. B. Clarke in Trans. Linn. Soc. ser. 2, Bot. vol. i. p. 495), sori (magis quam in *Allantodia* ipsa) allantodioidei sunt. In pluribus *Diplaziis* autem in herbario affixis, sori in dorso fracti a margine non dehiscentes visi sunt: præterea fide Beddomei in agro visa viva hæc *Eudiplazia* haud raro soros pseudallantoideis exhibent. Genera Filicum e venatione potius quam ex involucris olim ordinanda sunt.

24. ASPIDIUM PRESCOTTIANUM, *Wall.*, var. *β.* BAKERIANA (sp.), *Atkinson MS.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 510.

Adde: Baker in Hook. Ic. Pl. t. 1656; quo loco Baker hanc varietatem pro specie habuit.

25. ASPIDIUM ARISTATUM, *Sw.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 511. Var. typica partim, i. e. *A. coniifolio* (cum syn.) excl.—Lastrea aristata, *Bedd. Ferns Brit. Ind.* t. 261, partim, *i. e.* rhizoma in angulo sinistro superiore depictum.—Rhizoma repens, divisum, $\frac{1}{6}$–$\frac{1}{4}$ unciam crassum: stipites subdistantes in rhizoma continuo transeuntes; squamæ in rhizomate (cum squamis consimilibus in basi stipitum) $\frac{1}{6}$–$\frac{1}{4}$ unciam longæ, lanceolato-subulatæ, densæ, patulæ, brunneæ unicolores. Frondes mediocres (c. 12–18 uncias longæ), 2-pinnatæ aut sub-3-pinnatæ.

Planta in India australi, Zeylania, Malaya, Polynesia, frequens: in India boreali nondum lecta.

Var. CONIIFOLIA, *Wall. List*, n. 341, *non Thwaites*; rhizoma breve crassum, sæpe fere arborescens e terra exsertum, suberectum, apice a stipitibus stipatis coronatum; squamæ in basi stipitum $\frac{1}{2}$ unciam (et ultra) longæ, lanceolato-subulatæ, densæ, suberectæ, brunneæ unicolores. Frondes sæpe magnæ (usque ad 4–5 pedes longæ) 3-pinnatæ interdum 4-pinnatæ segmentis ultimis angustis.—*Bedd. Ferns Brit. Ind.* t. 261, partim, *i. e.* quoad pinnam depictam.

In India boreali communis.

Forma *affinis* (sp.), Wall. List, n. 370; var., C. B. Clarke in Trans. Linn. Soc. ser. 2, Bot. vol. i. p. 511, cum syn. et cum var. *Assamica*, l. c.: rhizomate squamisque omnino ut in var. *coniifolia*, Wall., sed fronde (sæpius magna) minus (interdum multo minus) secta.—Lastrea aristata, *Bedd. Ferns Brit. Ind.* t. 228; *Bedd. Ferns South Ind.* t. 101.

Forma in omni India cum Burma lecta.

Var. THWAITESII, *Thwaites, C. P.* n. 3938; caudice erecto, squamis in dimidio inferiore stipitis late ovatis, in medio sæpe castaneis; fronde 1–2-pedali 2–3-pinnata, soris involucratis, in facie inferiore frondis sitis.

Zeylania; in provincia centrali copiosa (*Thwaites*).

Forma *anomala*; soris in facie superiore frondis sitis, involucro caduco aut forsan interdum obsoleto.—Thwaites, C. P. n. 3504. *Polypodium anomalum*, Hook. in Kew Gard. Misc. vol. viii. p. 360, t. 11.

Zeylania; alt. 5000–7000 ped. (*Thwaites*).

26. NEPHRODIUM CUSPIDATUM, *Hook. et Baker*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 512.

Adde: rhizoma horizontale breve, stipitibus approximatis.

27. NEPHRODIUM GRACILESCENS, *Hook.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 512. Varietates et formæ a C. B. Clarke sub unica specie enumeratæ, ex sententia Beddomei 2 vel 3, ex sententia Bakeri 3 vel plures species bonas constituunt: sed species a Baker propositæ cum speciebus Beddomei non conterminæ sunt. Sequitur enumeratio formarum:—

a. ASPIDIUM GRACILESCENS, *Blume*!; rhizomate horizontali, stipitibus approximatis robustioribus, venis indivisis.—Nephrodium gracilescens, *Hook. et Bak. Syn. Fil.* p. 262, typ.

Ab India boreali nondum recepta.

b. ASPIDIUM GLANDULIGERUM, *Kunze*!; rhizomate elongato tenui, stipitibus sæpe distantibus, fronde tenuiore in superficie inferiore glanduligera, involucris ciliatis, venis indivisis.—Nephrodium gracilescens, var. β, *Hook. et Bak. Syn. Fil.* p. 262.

In China. In Khasia vulgaris, alt. 4000 ped., *C. B. Clarke* nn. 37395, 44338, 42903, &c. &c.

c. NEPHRODIUM GRACILESCENS, var. HIRSUTIPES, *C. B. Clarke, in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. tab. 67. fig. 1; rhizomate brevissimo, stipitibus subcæspitosis robustioribus basi hirsutis, venis indivisis.—*Bedd. Ferns Brit. Ind.* t. 253, fide Beddomei ips.

Hanc plantam Beddome mecum ut var. *N. gracilescentis* æstimat: Baker autem pro specie maluit.

Nephrodium gracilescens, var. *didymochlænoides*, C. B. Clarke, l. c. tab. 67. fig. 2, est *hirsutipidis* mera forma (*Beddome, Baker, C. B. Clarke*).

d. NEPHRODIUM FLACCIDUM, *Hook. Sp. Fil.* vol. iv. p. 133, t. 263; stipitibus subcæspitosis, fronde flaccida molli, rhachide pinnarum quasi-alata, pinnarum segmentis pinnatifidis, venis (fere omnibus) furcatis.

In Sikkim et Khasia, alt. 3000–6000 ped. frequens, *C. B. Clarke* nn. 38514, 44590, &c.

Certissime pro specie habenda fide Beddome et Baker.

Forma (mihi) rhachide obscure aut obsolete alata.—C. B. Clarke n. 40533 (cum multis aliis inter hunc numerum et *N. flaccidum*, typ. intermediis); Baker huic n. 40533 nomen flaccidum tribuit Beddome nomen nullum tribuit: Beddome enim speciem *N. flaccidum* in rhachide pinnarum quasi-alata (ut charactere essentiali) stabilivit.

e. NEPHRODIUM GRACILESCENS, var. DECIPIENS, *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. tab. 65. fig. 2; stipitibus subcæspitosis, fronde flaccida, venis paucis (aut nullis) furcatis.—"Verosimiliter species distincta," *Bedd. Handb Ferns Brit. India*, p. 234. Contra *Nephrodii hirsutipidis* (sp. Baker), var. ex sententia Bakeri.

Khasia, alt. 5000 feet, *C. B. Clarke* nn. 45466, 45655.

Hæ plantæ Baker ad var. decipientem retulit; Beddome his plantis nomen non dedit. Mihi hi numeri cum var. decipiente conjungendi; sed a *Nephrodio flaccido* forma n. 40533, vix diversi videntur.

28. NEPHRODIUM CANUM, *Hook. et Baker*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 515.

Simla, *H. Blanford*; rhizomate horizontali brevi: sed in *N. prolixo* typ. C. B. Clarke n. 44652 rhizoma omnino simile videri potest.

29. NEPHRODIUM SPARSUM, *D. Don*, var. 2, latisquama, *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 524, est *N. pulvinuliferum*, cf. C. B. Clarke in Journ. Linn. Soc. vol. xix. p. 289.

30. NEPHRODIUM OTARIA, *Baker in Hook. et Baker, Sp. Fil.* p. 288.

Assam; Shillong, alt. 5300 ped., *G. Mann.*

In India boreali antehac ignota.

31. NEPHRODIUM PROCURRENS, *Hook. et Baker*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 530.

Var. ? *microloba*; pinnis usque ad $\frac{1}{3}$ partem vix divisis.

Assam; Nambre Forest, *C. B. Clarke* n. 40811.

Rhizoma tenue, elongatum: pinnæ fere *N. pennigeri.*

32. NEPHRODIUM AMBOINENSE, *Presl*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 532.

Var. β. *evoluta*; fronde magna; pinnis magnis distantibus.

Assam; Shillong, alt. 3500 ped., *C. B. Clarke* nn. 44509, 44528, 44534.

Ex sententia Beddomei species nec var.

33. NEPHRODIUM CICUTARIUM, *Hook. et Baker*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 539.

Var.? *dubia*; magna; stipitis basi a squamis lanceolatis nigris pendentibus ornata; fronde lanceolata 1-pinnata; pinnis 6 paribus semipinnatis, 2 imis bifurcatis; soris magnis biseriatis.

Assam; Luckimpore, *C. B. Clarke* n. 37819.

In herb. C. B. Clarke sub nomine *N. decurrens*, var. *exalata*: ex sententia Bakeri forma inter *N. cicutarium* et *N. pachyphyllum* intermedia, verosimiliter species bona.

34. POLYPODIUM AMŒNUM, *Wall.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 550.

Forma *pilosa*; fronde subtus in superficie copiose breviter pilosa.

Khasia; frequens, *C. B. Clarke* nn. 44274, 44822, &c.

35. POLYPODIUM SUBAURICULATUM, *Blume, Fl. Jav. Fil* p. 177, t. 83; pinnis numerosis approximatis, basi angustatis rarius subauriculatis, anguste lanceolatis, subintegris aut serratis; areolis 1-serialibus in tab. Blumei (aut sæpius 2-serialibus); soris 1-serialibus conspicue immersis (*i. e.* pinnis verrucosis).

Khasia, *Simons* n. 282 *in h. Kew.* (exemplum unicum a Khasia visum).

Malaya, Australia, Polynesia, copiosa.

Goniophlebium subauriculatum, Bedd. Ferns Brit. Ind. t. 78, ab exemplo Javensi depictum fide auctoris ips. huc spectat: *P. argutum*, Wall., forma geographica *P. subauriculati* erit.

36. P. ARGUTUM, *Wall.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 551; pinnis (quam in *P. subauriculato*) minus numerosis, minus approximatis, venatione laxiore, basi angustatis aut subauriculatis; areolis 1-serialibus aut 2-serialibus; soris 1-serialibus, non immersis.

Himalaya; vulgaris. Khasia; frequens.

Forma *khasiana*; pinnis lanceolatis (quam in *P. subauriculato* sæpius latioribus), basi sæpe subauriculatis, haud raro conspicue auriculatis; areolis 2-serialibus; soris 1-serialibus non immersis.

—P. subauriculatum, *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 551 (exempla Khasiana omnia nisi exemplum Simons n. 282).

Khasia; vulgaris.

37. POLYPODIUM CYRTOLOBUM, *J. Smith*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 563.

Khasi; alt. 5000 ped., *C. B. Clarke* n. 45819.

Species in Khasia antehac non lecta: sed forsan a *P. hastato*, Thunb., var. *oxyloba* vix diversa.

38. POLYPODIUM JUGLANDIFOLIUM, *D. Don*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 566.

Var. PAUPER; fronde 1–3 unc. longa, lanceolata, indivisa, integra, per totam longitudinalitatem sæpe fere sorifera.

Khasia; alt. 3000 ped., in ripis fluminis Umian, *C. B. Clarke* nn. 37267, 40657.

Varietas decipiens: a Beddome juxta *P. Griffithianum*, a Bakero juxta *P. ovatum*, primo locata.

39. OPHIOGLOSSUM RETICULATUM, *Linn.*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 586.

Adde habitat: Parasnath, Chota Nagpore, alt. 2500 ped.

40. LYCOPODIUM SELAGO, *Linn. Sp. Pl.* p. 1565.

Khasia; Maophlang, alt. 5800 ped., *C. B. Clarke* n. 38965; Myrung, *Griffith*.

Exemplum parvum Griffithii, in plagula *Lycopodii zeylanici* infixum, a C. B. Clarke olim prætervisum.

41. LYCOPODIUM CASUARINOIDES, *Spring*; *C. B. Clarke in Trans. Linn. Soc.* ser. 2, *Bot.* vol. i. p. 593.

Var. PECTINATA, *Baker*; foliis divaricatis conspicue albo-aristulatis, inflorescentia depauperata.—*Hook. Ic. Pl.* t. 968. fig. 4.

Khasia; alt. 500 feet (Soyung &c.) sat communis.

Var. *eximia*, a Gustav Mann pro specie propria habita, in Khasia collibus facile distinguenda: sed exempla a montibus Borneo in herb. Kew. conservata intermedia sunt.

Diagnoses Plantarum Novarum Orientalium. By Dr. GEORGE E. POST, Beyrout, Syria. (Communicated by J. G. BAKER, Esq., F.R.S., F.L.S.)

[Read 19th April, 1888.]

THE diagnoses and descriptions following are those of species and varieties discovered by the author in Syria and the adjacent regions of Asia Minor. All references to species and other botanical subdivisions are to the 'Flora Orientalis' of Boissier. The plants described have been carefully compared with the nearest allied species in the Herbaria of M. Boissier at Geneva, and of the Royal Gardens at Kew, to the authorities of both of which establishments the author is indebted for much aid, which he desires gratefully to acknowledge. For convenience of reference, the varieties have been put in the order of the species.

I. RANUNCULACEÆ.

RANUNCULUS ARVENSIS, *L.*, var. **ROSTRATUS**. Disci spinæ breves, sæpe ad tuberculos reductæ; marginis spinæ breves, sæpe ad dentes reductæ; carpellum in rostrum subulatum arcuatum ovario duplo brevius abeuns.

Hab. Libanus; Bethel, Palestinæ; Haurân.

R. ARVENSIS, *L.*, var. **LONGISPINUS**; marginis spinæ ovario longiores.

Hab. prope Berythum.

II. PAPAVERACEÆ.

PAPAVER RHŒAS, *L.*, var. **PINNATUM**. Hispidissimum; folia caulina intermedia petiolata imparipinnata 3–4-jugis, foliolis oblongis grosse et irregulariter serrato-incisis segmento terminale obovato truncato grosse serrato-lobato, capsula obovata.

Hab. Kaftîn ad radices Libani prope Tripoli.

The single specimen, which was presented to the writer by Mr. Daûd Eesa, is more robust than *P. Rhœas*, L., var. *syriacum*, Boiss., and far more hispid. The leaves are from 4–6 inches long, and the leaflets from ¾–1½ inch long, very coarsely toothed. A smoother specimen, with similar pinnate leaves (125 'Plantæ Syriæ Littoralis,' under var. *syriacum*, Boiss. in

Herb. Kew), resembles it in all but the club-shaped umbonate capsules. Further study will probably reduce *P. umbonatum*, Boiss., *P. stylatum*, Boiss. et Bal., *P. clavatum*, Boiss. et Haussk., *P. commutatum*, Fisch. et Mey., and *P. polytrichum*, Boiss. et Ky., to varieties of *P. Rhœas*.

III. CRUCIFERÆ.

Hesperis aintabica. Perennis, parce pilosa, foliis inferioribus obtusis lyrato-pinnatifidis vel sinuato-dentatis, superioribus integris acutis, racemo elongato laxo ramoso, floribus violaceis petalorum limbo ungue duplo breviore, siliquis (junioribus) strictis, glabris.

Hab. prope Aintab; floret vere.

Closely allied to the Armenian *H. bicuspidata*, Willd., and *H. unguicularis*, Boiss., from which it differs by indumentum and entire stem-leaves.

Stems numerous, 1 foot high or more, woody at base from a woody root, green, narrowly paniculate above; lower leaves narrowly oblanceolate, 3–5 inches long, 4–7 lines broad, obtuse, tapering into a petiole; stem-leaves smaller, oblong and oblong-lanceolate, sessile, rather obtuse or acute; calyx violet; flowers 8 lines broad, pods stipitate.

Malcolmia auranitica. Annua, sparse glanduloso-puberula, caule fere a basi ramoso erecto, foliis ambitu linearibus runcinatis, floribus roseis, petalorum laminis oblongo-obovatis, siliquis (junioribus) parce papillosis.

Hab. in agro ad viam prope Sowarat-es-Saghîrah, ditionis Haurân; floret Maio.

Near *M. runcinata*, C. A. Mey., from which it differs by the indumentum, the shape of leaves and petals, and the pedicelled flowers.

A small herb, the single immature specimen being 3 inches high; the lower leaves 1½ inch long, 2–3 lines broad, with minute sparingly dentate lobes 1–1½ line long, ½–1 line broad; racemes few-flowered, simple; the pedicels half as long as calyx; sepals erect, green, sparingly papillose, obtuse, narrowly scarious at margin; petals pink, 5 lines long.

M. zachlensis. Annua, patule pubescens, caule simplici

erecto, foliis ambitu linearibus pinnatifidis, floribus roseis, petalorum laminis oblongis integris, siliquis (junioribus) hirtis.

Hab. in agris prope Zachleh, Cœlesyriæ; floret Aprili.

Near the last; but differs from it and *M. runcinata*, C. A. Mey., by the pinnatifid (not runcinate) leaves, with oblong or triangular entire lobes.

A small herb, the few immature specimens not exceeding 3 inches in height, leaves 1–2 inches long, 2–2½ lines broad, lobes 1½ line long, 1 line broad; racemes few-flowered, loose; pedicel half as long as calyx; sepals crisply papillose, erect, oblong obtuse.

ÆTHIONEMA LONGISTYLUM. Perenne, caulibus rigidibus basi ligneo ascendentibus, foliis coriaceis oblongo-linearibus obtusis turionum sterilium confertis ramorum fertilium paucis, floribus . . . . siliculis oblongo-rotundatis apice emarginatis alis angustis vix inflexis, stylo sinu angusto æquilongo vel longiore.

Hab. in excelsis montis Jebel-el Fughri, Libani; Kai-pok-dagh, Amani infra cacumine; floret Julio.

Near *Æ. coridifolium*, DC.; but differs in the more woody stems, longer leaves, but principally in the large, nearly flat pods, with spreading pedicels, and style as long as sinus, or longer.

A shrubby plant, 6–10 inches high, with branching stem; leaves of sterile stems nearly rosetted at end, an inch or more long, 2–3 lines broad, those of fertile stems a little smaller, all very obtuse; pods 3–4 lines long, 2½–3 lines broad, with narrow wing and 1-ovuled cell; seed 1½ line long, 1 line broad.

Æ. GILEADENSE. Glabrum, parce ramosum, foliis inferioribus petiolatis obovatis margine undulatis, caulinis linearibus acutis, floribus . . . . racemis fructiferis elongatis laxis, siliculis obovato-orbiculatis basi retusis apice vix emarginatis, alis loculi diametro æquantibus radiato-plicatis involutis crenatis tandem fimbriatis, stigmate sessili.

Hab. in umbrosis prope Es-Salt, ditionis Gilead; floret Martio.

Near *Æ. clandestinum*, Del., of which I have seen specimens in Boissier's Herbarium, but neglected to note the distinguishing characteristics.

A plant with shrubby base, 8 inches high, lower leaves 3 lines long, as long as petiole; stem-leaves 5 lines long, 1½ line broad, silicle 2½ lines long. The specimen from which the above description was made has few fruits and no flowers.

IV. SILENEÆ.

Dianthus multipunctatus, *Ser.*, var. **pruinosus.** Indumentum pruinosum.

Hab. ad rupes calidos ad viam inter Hierosolymam et Jericho.

D. floribundus, *Boiss.*, var. **kerhanicus.** Folia et caules pruinoso-scabridi; flores rarius bini, sæpius solitarii; petala siccitate flava.

Hab. prope Kerhân ad radices australes montis Akherdagh, Syriæ borealis.

D. auraniticus. Glaber glaucescens, caulibus parce ramosis, floribus axillaribus vel terminalibus solitariis magnis longe pedunculatis, squamis quaternis oblongo-lanceolatis apice patulis scarioso-marginatis in cuspidem viridem acutam patulam vel ascendentem abruptiuscule attenuatis, calycis squamis 2½plo longioris dentibus triangulari-lanceolatis mucronatis, lamina obovato-spathulata parce dentata.

Hab. in agris inter Irbid et Bosrah, ditionis Haurân; floret Junio.

Near *D. judaicus*, Boiss., but readily distinguishable by glabrescence, branching stems, and longer scales. (§ 2. *Leiopetali*· * Flores solitarii, † Squamæ subquaternæ.)

A plant 1 foot high, with somewhat the aspect of *D. Libanotis*, Labill., but more slender, and with sparingly *dentate*, not *fimbriate*, petals, with erect branching stems; leaves 1–2 inches long, linear acute, plicate-canaliculate, narrowly white-margined, the lower imbricated, dilated at base; scales 5–6 lines long; calyx 14–16 lines long, striate; colour of (immature) petals not determinable.

Silene Porteri. Perennis, pruinoso-scabrida, caulibus paucis humilibus, unifloris vel parce dichotomis 2–3-floris, foliis radicalibus brevibus lineari-spathulatis, intermediis acutis, superioribus subulatis brevissimis, calycis anguste cylindrici elongati rubrovittati dentibus ovato-triangularibus margine scariosis ciliatulis, lamina obcuneata bifida, coronæ lobis cuspidatis, capsula ovato-oblonga calyce sublongiore carpophoro breviore.

Hab. sub cacumine montis Ziaretdagh Amani, et in monte Akherdagh, 7000 ped.; floret Junio.

A plant in § 23. *Sclerocalycinæ*, Boiss. Fl. Or. I. p. 638, near *S. Makmeliana*, but distinguished by characteristics pointed out in the Supplement to the 'Flora Orientalis' of Boissier, which at the time of writing is in the press.

Stems shrubby at base, ½–1 foot high; slender, simple or sparingly branched; root-leaves 1–1½ inch long, 2 lines broad; calyx narrow, 1 inch long.

V. ALSINEÆ.

Arenaria graveolens, *Schreb.*, var. **minuta**. Folia 2½ lineas longa lineam lata; flores vix lineam longi; planta tota delicatula.

Hab. in sylvaticis ditionis 'Ajlûn.

VI. PARONYCHIEÆ.

Paronychia nivea, *DC.*, var. **obtusa**. Bracteæ obtusiusculæ vel breviter acuminatæ.

Hab. ad vias in Jebel Husha' ditionis Gilead.

P. nivea, *DC.*, var. **attenuata**. Caules elongati, internodii foliis caulinis minutis multo longiores bractearum argentearum destituti; capitula pauca versus apicem caulis congesta; bracteæ oblongæ et ovatæ acutæ.

Hab. ad radices dumorum inter 'Ain Hesbân et 'Ammân, ditionis Moab.

A strongly marked variety, with stems 3–5 inches long, stem-leaves 2–5 lines long, and heads in terminal cymes, yet seeming to lack sufficient characteristics to warrant its description as a species. Intermediate forms between it and the type should be sought.

P. argentea, *Lam.*, var. **scariosissima**. Bracteæ caulinæ foliis numerosiores scariosissimæ, folia fere occultantes.

Hab. in agris et ad vias prope Antiochiam.

A well-marked variety, conspicuous by its large silvery bracts.

VII. MALVACEÆ.

Malva sylvestris, *L.*, var. **oxyloba.** Folia acute 3–5-lobata, lobis argute dentatis.

Hab. ad Tel-er-Ramé, ditionis el-Ghor.

A specimen of this variety from near Leghorn is found in the Kew Herbarium, from the herbarium of J. Gay; also one from Transylvania.

Alcea acaulis, *Cav.*, var. **longipes.** Pedunculi flore æquilongi vel longiores.

Hab. ad radices montis Carmeli.

This species is not happily named, as it is often caulescent, and sometimes with rather long trailing or ascending stems.

VIII. LINACEÆ.

Linum rigidissimum. Basi suffruticosum, caudiculis tortuosis numerosis, foliis puberulis glaucescentibus carnosis turionum sterilium confertis imbricatis minutis oblongo-obovatis acutatis margine albo minute denticulatis, ramorum fertilium lineari-oblanceolatis, ramis fertilibus erectis foliosis apice laxe corymbosis, floribus . . ., capitulis sphæricis breviter acuminatis.

Hab. in vallibus ad radices montis Kapucham-Dagh prope Marash; floret æstate.

A plant 6–8 inches high, shrubby at base, well distinguished from other Linums by the small rosettes of imbricated leaves 2–3 lines long and broad on the sterile branches; the scattered stem-leaves are 4–5 lines long, 1 line broad; ripe capsules 2½ lines broad. This species would seem to constitute a new section in the genus *Linum*, nearest to *Syllinum*. Its place can only be determined when flowering specimens are obtained.

IX. LEGUMINOSÆ.

Genista albida, *Willd.*, var. **biflora.** Indumentum sericeum; flores sæpius gemini racemos longos foliaceos formantes; foliola oblongo-obovata 3 lineas longa.

Hab. Amasia, Asiæ Minoris.

Cytisus drepanolobus, *Boiss.*, var. **hirsutissimus.** Rami foliaque hirsutissimi; foliola parva 4–6 lineas tantum longa elliptico-lenticularia.

Hab. Amasia, Asiæ Minoris.

TRIGONELLA NOËANA, *Boiss.*, var. MINOR. Nana, 2–3-pollicaris; flores sæpius gemini 2–4 in tota planta; legumina eis typi breviora.

Hab. prope Aintâb.

T. CYLINDRACEA, *Desv.*, var. LILACINA. Flores lilacini.

Hab. ad viam Berytho.

MEDICAGO SHEPARDI. Annua, pubescens, caulibus ascendentibus, stipulis subintegris, foliolis minutis obovato-cuneiformibus, pedunculis folia excedentibus gracilibus 2–4-floris, floribus parvis, legumine pubescenti minuto plano bispiro crebre et radiatim venoso-reticulato, venis ante marginem subintegrum in nervum elevatum flexuosum minute tuberculatum margini parallelum anastomosantibus.

Hab. in Syria boreali prope Aintab; floret vere.

A small species in § *Pachyspiræ*, Urban, near *M. obscura*, Retz., =*M. Helix*, Willd., from which it differs by its nearly entire stipules, glabrous pod, &c.

The name was given in honour of Mrs. Shepard, M.D., an enthusiastic and careful collector.

TRIFOLIUM CANDOLLEI. Annuum, parce et adpresse pubescens, stipulis parte libera lineari-subulatis, foliolis parvis ellipticis integris, capitulis longe pedunculatis sæpius binis floriferis obovatis, fructiferis oblongo-ovatis, calycis sericei, corolla rosea 2½–3plo brevioris laciniis erectis rigidis subulatis plumosis subæqualibus tubo turbinato apice truncato subæquilongis, fauce clauso.

Hab. prope Aintab; floret Maio.

A delicate and pretty pink-flowered species near *T. Alexandrinum*, but differing by the silky calyx with equal subulate teeth, small leaves, and linear-subulate stipular appendices.

Stems branching from base, prostrate or ascending; branches slender, 6–8 inches long; leaves 4–6 lines long, 2–3 lines broad; heads 6–9 lines long, 5–7 lines broad, smaller in fruit; calyces erect in fruit, imbricated.

T. ALSADAMI. Annuum, nanum, patule pubescens, ramis tenuibus rigidis erectis, stipulis parte libera lineari-subulata acuta, foliolis parvis, capitulis parvis, calycis hirsuti eximie 10-costati, corolla albida basi attenuata duplo brevioris laciniis triangulari-acuminatis trinerviis tubo duplo brevioribus patentibus inferiore alteris subduplo longiore deorsum uncinata.

Hab. in agro ad radices montis Alsadami (Jebel Qulêb) inter Qurêyah et el-Kufr, ditionis Haurân.

A dwarf annual, near *T. maritimum*, L., but differing in its small, few-flowered heads, smaller leaves, and the long inferior lobe of the calyx.

Plant 3–4 inches high; stem branching from base; leaflets 3 lines long, 1½–2 broad, oblong obovate-cuneate, ciliate-margined; flowering heads twice as large as a pea, with white flowers; fruiting heads a little larger; calyx 2 lines long in flower, 4 lines in fruit.

Astragalus trachoniticus. Perennis, adpresse canescens basi suffruticens, caulibus nanis fere a basi ramosis, ramis erectis floriferis foliis brevioribus, stipulis lanceolatis acuminatis albo- et nigro-pilosis, foliolis 3–7-jugis oblongis vel linearibus acutis, pedunculis folio multo brevioribus, floribus 2–5 racemosis axi tortuoso, bracteis pedicello brevissimo longioribus lanceolatis, calycis albo- et nigro-pilosi dentibus lanceolatis subulatis tubo basi valde gibboso cylindrico sextuplo brevioribus, corolla quam calyx vix duplo longiore, leguminis erectis versus basin subarcuatis subpannosis linearibus sensim in rostrum eis octuplo brevius attenuatis.

Hab. ad viam prope Sowarat-el-Kebîrah, ditionis el-Lejâ (Haurân); floret Aprili.

A greyish-coloured species in the section *Xiphidium*, differing from its neighbours by its small size, erect pods, and few flowers.

Plant 3 inches high, overtopped by long upper pods; leaflets 3–5 lines long, 1 line broad; flowers pink, an inch long; pods somewhat terete or cylindrical, 2½ inches long, 2 lines broad.

Vicia narbonensis, *L.*, var. **pilosa.** Folia 1-juga. Legumina typo latiora, pilis basi tuberculatis obsita.

Hab. in sylvaticis inter es-Salt et Hesbân.

X. UMBELLIFERÆ.

Bupleurum Boissieri. Annuum, caulis erectus elongatus gracilis a basi dichotome ramosissimus, foliis lineari-lanceolatis acutis striatis, ramulis ramo adpressis, umbellulis sæpius binis altera longius pedunculata secus ramos stricte racemosis, involucelli phyllis oblongis trinerviis carinatis mucronatis umbellulam minimam paucifloram superantibus, fructus (junioris) lævis jugis acutis.

Hab. in sylvaticis montis Amani; floret Junio.

Near *B. tenuissimum*, Linn., but distinguished from it by its more densely branched stems, the oblong leaves of the involucel, and the smooth fruits.

Plant 1–2 feet high, primary branches spreading, flowering and fruiting branchlets appressed.

BUPLEURUM ANTIOCHIUM. Perenne, basi ligneum, caule erecto elato superne dichotome et anguste paniculato, foliis lanceolato linearibus acutis tenuiter quinquenerviis basi sensim angustatis sessilibus, umbellis parvis subæqualiter 2–3-radiatis, involucri et involucelli phyllis minutis triangulari-subulatis pedunculis et pedicellis multo brevioribus, fructu oblongo pedicello longiore, jugis alatis, valleculis 3–4-vittatis.

Hab. propre Yokoon-Alook, ditionis Amani; floret Septembro.

A plant in § 3 *Gramineæ* ** Fructus lævis †† Perennes (Boiss. Fl. Or. II. 835), near *B. rigidum*, L., but easily distinguished from it by its flaccid leaves with slender nerves; distinguished from *B. falcatum*, L., by its small 2–3-rayed umbels and much longer and more flaccid leaves.

Stem 2–3 feet high; lower leaves 6–8 inches long, 4–5 lines broad; fruit 2½ lines long. Flowering axis zigzag.

PIMPINELLA DEPAUPERATA. Perennis vel biennis, glabra, pallide virens, caulibus elatis teretibus rigidis subnudis dichotome et ample paniculato-ramòsis, foliis radicalibus petiolatis 1–2-pinnatipartitis ambitu oblongo-lanceolatis jugis primariis 8–10 secundariis 1–3 segmentis ovato-oblongis inciso-dentatis sectisve dentibus mucronatis, foliis caulinis paucis depauperatis petiolis sèmiamplexicaulibus in lacinias lineares breves 1–2-pinnatisectis, umbellis parvis trichotome dispositis pedunculis inæqualibus radiis 5–6 inæqualibus, pedicellis capillaceis subæqualibus fructu minuto glabro ovato subæquantibus stylopodiis depressis stigmate sessili superatis.

Hab. in rupestribus prope Aleih, Libani; floret Octobro.

In Sect. *Tragium*; perennial, readily distinguished from all its neighbours by its tall growth, 3–4 feet; its early marcescent root-leaves, 6–8 inches long, with greater segments an inch long, 4–5 lines broad; its slender, almost naked, much-branched stems with rudimentary leaves; its minute umbels, 6–7 lines broad; and its very minute fruit, half a line broad.

SCALIGERIA CAPILLIFOLIA. Radix minuta globosa, caule gracili tereto elato alternatim et patule ramosissimo, foliis radicalibus ambitu ovatis caulinisque in lacinias setaceas decompositis, umbellis breviter 3–4-radiatis, involucro nullo, involucelli phyllis subulatis acutis umbellulas 4–6-floras superantibus, pedicellis flore fructuque vix longioribus, petalis albis, fructu globoso stylopodio depresso mammillari stylisque brevibus deflexis superato nitido.

Hab. in sylvaticis Amani supra Hassan Beyley et in monte Akherdagh supra Marash; floret Septembro.

A plant with the aspect of *Carum setaceum*, Schr., = *Bunium capillifolium*, Kar. et Kir., but readily distinguished by the few-rayed primary and secondary umbels, and from its allies in Sect. II. *Elæosticta* by its globular root, leafy stem, and less tortuous branches, and subulate leaves of involucre and involucel. It has the globular mericarps, with concave internal face, of *Scaligeria*.

CARUM BRACHYACTIS. Glabrum, caule humili fere a basi parce et dichotome ramoso, ramis divaricatis, foliis radicalibus . . . . caulinis paucis parvis in lacinias paucas lineari-spathulatas divisis, umbellæ radiis 7–8 brevibus subæqualibus umbellulis parum longioribus, involucri et involucelli phyllis membranaceis lanceolato-subulatis radiis et pedicellis brevioribus vel subæquilongis, pedicellis gracilibus fructu oblongo brevioribus, stylis fructus diametro duplo stylopodio depresso sextuplo longioribus.

Hab. in monte Akherdagh, Syriæ borealis.

A plant of Sect. *Bunium*, near *C. Bourgæi*, Boiss., and *C. Pestalozzæ*, Boiss., differing in the very short equal rays of the primary and secondary umbels.

Root globular, sometimes lobed; plant 4–6 inches high, segments of upper leaves 2–3 lines long, ½ line broad; primary umbels 1 inch broad, radii 4–5 lines long; secondary umbels 3 lines broad; fruit 2 lines long, ¾ line broad.

C. NUDUM. Perenne, glabrum, caule tereti elato superne alternatim paniculatim ramoso, foliis radicalibus . . . . caulinis intermediis pinnatis 2-jugis, foliolis parvis oblongo-ellipticis acutis integris, superioribus ad petiola membranacea vaginantia scariosomarginata abrupte caudata reductis, umbellis inæqualiter 12–14-radiatis radiis umbellulæ fructiferæ diametro 2½plo longioribus, involucro nullo, involucelli phyllis paucis mox deciduis brevibus subulatis, fructu oblongo pedicello gracili breviore, stylis deflexis stylopodio depresso conico parum longioribus.

Hab. in monte Amano prope Beilân; floret Junio.

Near *C. elegans*, Fenzl, but well distinguished by the oblong-elliptical leaflets, and caudate upper petioles and short styles. A plant 1½–2 feet high, with sparingly branched stem; leaflets 4–5 lines long, 1½ broad; rays 1½ inch long; secondary umbels 15–20-rayed, 7–8 lines broad; fruit 2½ lines long, 1 broad.

CHÆROPHYLLUM OLIGOCARPUM. Perenne, caulis gracilis teres pluries dichotomus, ramis tenuibus rigidulis, foliis radicalibus petiolo plano dilatato membranaceo suffultis in lacinias paucas filiformes partitis, caulinis ad lacinulam lineari-setaceam sessilem reductis, umbellis secus ramulos tenues subsessiles brevissime 3–4-radiatis, involucri involucellique phyllis membranaceis minimis, umbellulis 5–6-floris, flore centrali unico fertile, fructu lineari-cylindrico basi attenuato stylis deflexis disco angusto longioribus superato, jugis elevatis.

Hab. in pinetis declivitatis orientalis infra cacumine montis Kai-pok-dagh Amani; floret Augusto.

Nearly allied to *C. macrospermum*, but readily distinguished by its almost naked, junciform, dichotomous stems, and its small, short-rayed umbels.

A plant, 1½ foot high, with short peduncled umbels loosely racemed along the slender branches; rays scarcely 2 lines long; fruit 01–11 lines long.

FERULAGO AMANI. Perennis, caulis elatus tenuis gracilis fere a basi ramosissime paniculato-subcorymbosus, angulatus, foliis radicalibus . . . caulinis et rameis ad vaginas breves lanceolato-lineares reductis ex quarum axillis in parte inferiore folium diminutum in lacinias subulatas dissectum oritur, umbellis parvis breviter et tenuiter 4–5-radiatis, involucris involucellisque brevissimis oblongo-triangularibus, mericarpiis (immaturis) oblongis pedicello tenui sublongioribus.

Hab. in regione intermedia declivitatis occidentalis Kai-pok-dagh Amani; floret Septembro.

The diagnosis, prepared by the author with the concurrence of the late lamented Boissier, shows that this plant is closely allied to *F. stellata*, Boiss. It is distinguishable by the peculiarities of the leaves, the small, short-rayed umbels (those of *F. stellata* having 8–12 rays 1–1½ inch long). The plant is 2–3 feet high, with nodes not thickened as in *F. Cassia*, Boiss., and narrower mericarps.

FERULAGO BLANCHEANA. Perennis, glabra glaucescens, caule elato angulato-sulcato superne thyrsoideo-corymboso, foliis maximis ambitu æquilongis ac latis in lacinias lineari-subulatas a costis indistinctas obtusas abrupte mucronulatas supra decompositas, involucris et involucellis brevissimis, lineari-lanceolatis deflexis, umbellis breviter 10–15-radiatis, floribus . . . . mericarpiis pedicello longioribus ellipticis jugis tribus dorsalibus prominentibus acutis margine latiusculo, vittis dorsalibus 7–8 commissuralibus sub senis.

Hab. in excelsis montis Akherdagh, supra Marash; floret Julio.

This species was diagnosed with the concurrence of M. Boissier, and separated from *F. thyrsoidea* on the ground of the shorter divisions of the leaves, the fewer vittæ, and larger mericarps. A plant 3–6 feet high, with panicles 1½ foot long in fruit.

F. AURANITICA. Perennis, ad caulem elatum superne corymbosum glabrescens glauca, foliis inferioribus amplis ambitu ovatis petiolatis pinnatim supradecompositis petiolis primariis et secundariis crassis brevibus laciniis oblongo-linearibus margine eximie papilloso-scabrido revolutis, superiorum lacinulis anguste linearibus, umbellis 12–14-radiatis, involucri involucellique phyllis longis capillaribus, pedicellis fructu longioribus, mericarpiis oblongis.

Hab. in agris prope Qurêyah, ditionis Auranitis (vulgo Haurân); floret Aprili.

Near *F. syriaca*, Boiss., but differs strongly by its leafy stem, the 3-pinnate dissected leaves subtending even the uppermost branches, while in *F. syriaca* they are reduced to scales; also in the long capillary involucres and involucels.

Plant 3–4 feet high; lower leaves including petiole 1 foot long; laciniæ 3–6 lines long; leaves of involucre an inch or more in length.

PRANGOS MELICOCARPA, *Boiss.*, var. **TRACHONITICA.** Tota crispe pubescens; foliorum laciniæ ciliatæ; planta typo procerior.

Hab. in scaturiginibus vulcanicis Tell-Shihân, ditionis Trachonitis (vulgo el Leja).

A plant with softer foliage than *P. Arcis-Romanæ*, and greyish crisp indumentum, distinguishing it from the type and the latter-named species. It is found not only on the volcanic cone of Tell-Shihân, but in the fields around its base.

Johrenia Porteri. Perennis, glaber glaucescens, caule tereti elato pluries stricte dichotomo nudo, ramis rigidis crassiusculis, foliis omnibus radicalibus ambitu oblongo-lanceolatis pinnatisectis segmentis senis cum terminali impari secus rhachidem sessilibus remotis ovatis grosse dentatis, umbellis aliis in dichotomiis subsessilibus depauperatis brevissime pauciradiatis aliis terminalibus inæqualiter 6–12-radiatis contractis, involucro nullo, involucelli phyllis deflexis breviter lanceolatis, pedicellis tenuibus fructu subbrevioribus, mericarpiis ovato-oblongis, area centrali plana a margine fungoso albo distincta, commissura plana pruinosa.

Hab. in collibus apricis ditionis Kapu-Cham, prope Marash; floret Julio.

Near *J. fungosa*, Boiss., from which it differs in the naked stems, the peculiar arrangement of umbels, absence of involucre and involucel, short pedicels, &c. It differs from *J. selinoides* by its 1- not 2-pinnatisect leaves with ovate not linear segments.

Plant 3 feet or more in height; segments of leaves 8–9 lines long, pinnatisect; mericarps 2 lines long.

Daucus jordanicus. Annuus, sparsissime papillosus glabrescens, caule crasso elato a basi dichotome ramoso, foliis ambitu oblongis petiolo non inflato suffultis 2–3-pinnatipartitis divisionibus primariis et secundariis petiolulatis laciniis oblongo-linearibus obtusis, umbellis longe pedunculatis inæqualiter 8–12-radiatis, involucri phyllis persistentibus linearibus viridibus apice callosis, involucelli phyllis ovatis acuminatis albo-scariosis margine ciliatis pedicellis brevioribus, petalis extus glabris late obcordatis, fructibus pedicellis subduplo brevioribus setis valde inæqualibus obsitis jugorum secundariorum glochidiatis fructus diametro subduplo longioribus, primariorum brevibus muticis, stylopodiis conico-elongatis stylis quadruplo longioribus superatis.

Hab. in herbidis ditionis el-Ghor, Jordani vallis; floret Aprili.

This species has the large umbels and flowers of *D. pulcherrimus*, but is readily distinguished from it by the involucre, the non-inflated petiole, the much smaller fruits, resembling those of a *Psammogeton*, and the dense bristles of the primary ribs.

Plant 2 feet high, lower stem-leaves 4 inches long, laciniæ 2–3

lines long, ¼ line broad, flowers 1½–2 lines broad, fruit (without bristles) 1⅓ line long, ⅓ broad.

XI. RUBIACEÆ.

Galium cymulosum. Humile, caule erecto glabro superne parce dichotomo cymuloso, foliis parvis quaternis elliptico-lenticulis obsolete trinerviis margine scabridulis, cymis terminalibus et ex axillis superioribus foliosis contractis 3–8-floris, pedicellis flore brevioribus fructiferis erectis, fructu glabro sæpius inæqualiter didymo.

Hab. in sphagneis sylvaticis montis Amani; floret Augusto.

A dwarf plant of Sect. I. *Eugalium*, § 1. *Platygalia*, but with indistinct lateral nerves, nearest to *E. valantioides*, but distinct by its smaller size, smaller elliptical not rhomboid leaves, with less marked nerves, few flowers in almost sessile cymules subtended and almost concealed by two oblong leaves longer than themselves.

Plant 3–5 inches high, leaves 3–4 lines long, 1½–2⅓ broad, cymules 2–3 lines broad.

G. lanuginosum. Perenne, basi suffruticosum, totum patule lanuginosum canum, caulibus erectis crassiusculis, foliis elliptico-rhomboideis margine revolutis, cymis axillaribus pedunculatis.

Hab. prope Hadjin in Tauro.

As the specimen is not in flower it is not possible to determine its affinity. It has the aspect of a neighbour of *G. canum*, but is quite distinct in indumentum and form of leaves. Stems 3–6 inches high, leaves 3–5 lines long, 2–3 broad.

Asperula dissitiflora. Perennis, minute scabridula, siccitate nigrescens, rhizomate repente lignoso, caulibus numerosis elongatis tortuosis inferne induratis debilibus procumbentibus, foliis senis oblongo-ellipticis obtusis vel mucronulatis, floribus solitariis rarius 2–4-cymulosis, pedunculis pedicellisque gracillimis folio brevioribus ex axillis superioribus, corollæ (siccitate albovirentis) tubo lobis ovato-oblongis parum breviore, antheris oblongis exsertis, ovario minuto globuloso apice truncato.

Hab. in sylvaticis Amani; floret æstate et autumno.

A plant of Sect. VI. *Cynanchica*, § 6. *Brachyantha*, having no near congeners, distinguished from most of the *Asperulæ* by its flaccid Galioid stem and leaves, and scattered minute flowers.

Stem 1–1½ foot long, leaves 4–6 lines long, 2 broad, pedicels 1½ line long; fruit half a line in diameter.

Scabiosa ochroleuca, *Linn.*, var. **intermedia**. Indumentum subpannosum, folia inferiora oblonga basi in petiolum longum marginatum attenuata obsolete crenata, superiora plus minusve lyrato-pinnatipartita, segmenta cuneato-oblonga crenata, lateralibus terminali multo minoribus, flores cærulei vel rubelli.

Hab. in rupestribus Amani; floret Septembro.

This variety is quite intermediate between *S. ochroleuca,* Linn., and *S. taygetea,* Boiss. et Held., and establishes the unity of the two species.

XII. COMPOSITÆ.

Erigeron setiferum. Bienne, caule elato striato setoso foliosissimo superne stricte ramosissimo, foliis anguste lineari-lanceolatis utrinque attenuatis acutis viridibus ad margines nervumque albo-setosis, rameis subulatis, racemis confertifloris paniculam elongatam polycephalam formantibus, capitulis minimis hemisphæricis pedicellis filiformibus eis vix longioribus suffultis, involucri pallidi glabro vel parce setulosi phyllis anguste linearibus obtusis anguste albo-marginatis intimis pappum subæquantibus, floribus femineis paucis filiformibus, acheniis hirtis columnaribus pappo sordido uniseriali dimidio brevioribus.

Hab. in paludosis Syriæ borealis ad Pylas Syriacas.

A tall species, nearest to *E. Aucheri,* 3–6 feet high, with a panicle 1–2 feet long; the stem-leaves an inch to scarcely a line and a half broad, the upper gradually smaller; heads $\frac{1}{3}$–$\frac{1}{4}$ as large as those of *E. linifolium* and *E. ægyptiacum,* $1\frac{1}{4}$ line long and broad. Readily distinguished by the white pectinate hairs of the leaves, and the very numerous minute heads.

Achillæa Shepardi. Perennis, adpresse albo-lanuginosa, caulibus simplicibus superne corymboso-capitulatis, foliis inferioribus petiolatis ambitu obovatis 2–3-pinnatipartitis laciniis oblongis minutis obtusis, foliis caulinis paucis depauperatis 1-pinnatisectis, corymbo terminali denso composito, involucri obovati dense lanuginosi phyllis oblongis obtusissimis valde inæqualibus, floribus omnibus tubulosis flavis.

Hab. prope Amasia, Asiæ Minoris; floret æstate.

A plant to be placed in § 2. *Filipendulæ,* distinguished by silky indumentum, almost naked stem, and compact corymb of yellow flowers.

One foot high; nearly all the leaves inferior, 10–15 lines long, somewhat fan-shaped, 6–8 lines broad; stem-leaves 3–6 lines long; laciniæ 1–2 lines long.

Cirsium Amani. Bienne, bipedale vel procerius, caule papilloso-pubescenti striato versus apicem parce ramoso, ramis monocephalis, foliis firmis supra glabris strigosis subtus minute araneosis oblongis sinuato-lobatis lobis acutis acute lobato-dentatis capitulis mediocribus foliis summis involucratis, involucri glaberrimi phyllis linearibus margine ciliatulis in spinulas tenuissimas flavidas erectas flores duplo breviores attenuatis.

Hab. in cacumine montis Amani supra Hassan Beyley.

Not nearly allied to any oriental species, distinguished by few solitary terminal heads longer than a hickory nut, non-decurrent leaves, and fibrous roots spreading laterally from neck. Plant 2–3 feet high.

Centaurea Doddsii. Perennis, caule elato inferne pilis undulatis crispis obsito, superne araneoso remote 8–14-cephalo, foliis firmis papillosis radicalibus longe petiolatis ovatis basi subcordatis integris vel subrepandis, caulinis inferioribus oblongo-lanceolatis acutis basi in petiolum alatum longe attenuatis, superioribus linearibus sessilibus sensim diminutis, capitulis magnis globosis basi truncatis pedunculis eis brevioribus suffultis, involucri glabri phyllis latis stramineis margine crebre pectinato-spinulosis spinulis debilibus, intermediis in spinam stramineam, eis longiorem attenuatis, flosculis . . . . acheniis . . . . .

Hab. in planitie Antiochiæ ad radices montis el-Jebel-el-Ahmar (Ghizil-Dagh) Amani; floret Julio.

Sect. VII. *Acrocentron* . . . . *Cynaroideæ*, nearest to *C. Haussknechtii*, Boiss., but differs from it in being a taller plant (3 feet or more in height), in its crisp undulating indumentum, in its longer simple leaves, ovate-cordate at base, a foot in length, and 3–4 inches broad, and larger heads (an inch long). Named formerly, in a schedule submitted to M. Boissier, *C. polycephala*.

C. trachonitica. Perennis, subacaulis, radice crasso verticali, foliis omnibus radicalibus vel ad basin pedunculorum insertis rosulatis firmiusculis strigosis lyrato-pinnatisectis, segmentis parvis valde inæqualibus oblongis et oblongo-lanceolatis obtusis vel acutis mucronatis plus minusve irregulariter dentatis decurrentibus, capitulis 8–15 breviter pedunculatis ovatis majusculis, involucri glabri phyllis ovatis virido-rubellis superne albo-ciliatis in spinam inferiorum brevem intermediorum phyllo 1–2-plo longiorem validem patentem vel reflexam abeuntibus intimis inermibus rubris apice scariosis ciliatis, flosculis purpureis, acheniis parce et adpresse sericeis parvis basi pilis flaviusculis obsitis, pappi albi basi aurantiaci serie intermedia achenio sesquilongiore interna subæquilonga.

Hab. in scaturiginibus vulcanicis ad radices montium Shuhbah, ditionis Trachonitis (vulgo el-Leja).

Near *C. Hellenica*, Boiss. et Sprun.; differs from it in the numerous heads, the stout spines of the involucre, strigose indumentum, pappus orange-coloured at base, the intermediate series larger and the inner as long as the achene.

XIII. CAMPANULACEÆ.

Campanula Trachelium, *L.*, var. **solitaria.** Flores solitarii vel gemini, calyx corolla parum longior; hisce notis exceptis, ad var. *orientalem*, Boiss., accedit.

C. amasiæ. Perennis, breviter retrorse hirta, radice fusiforme crasso, caulo simplici erecto striato racemo composito thyrsoideo abeunti, foliis radicalibus cito evanidis, caulinis sessilibus oblongis et oblongo-lanceolatis obtusis vel acutis obsolete denticulatis, fasciculis breviter pedunculatis 1–3-floris, calycis pedicellis longioris laciniis subulatis ascendentibus vel patentibus tubo turbinato 2–3plo longioribus, corollo obconica-campanulata pallide cærulea calyce sesquilongiore in lobos triangularibus lanceolatos fere ad medium secta.

Hab. prope Amasia, Asiæ Minoris; floret Junio.

Near *C. lanceolata* (Sect. *Saxicolæ*), but differs in indumentum, calyx-lobes two-thirds as long as corolla and narrowly triangular-lanceolate; corolla-lobes almost as long as tube.

Plant a foot or more high; flowers 10 lines long; stem-leaves 1–1½ inch long, 2½-4 lines broad.

XIV. BORAGINEÆ.

Anchusa Shattuckii. Annua, nana hispidula superne parce ramosa, foliis sessilibus oblongis obtusissimis inferioribus basi attenuatis integris, floribus nigro-purpureis brunneis racemos terminales pauciflores densiusculos formantibus, pedicellis calyce brevioribus fructiferis deflexis, calycis profunde quinquepartiti laciniis fructiferis parum auctis linearibus nuculas superantibus, corollæ calyce duplo longioris lobis rotundatis tubo exserto, fornicibus exsertis fulvis velutinis, nuculorum (juniorum) facie externo tuberculata.

Hab. in agris prope Aintab et Marash; floret Aprili.

A plant 3–4 inches high, erect, near *A. Milleri*, but distinguished from it by indumentum, entire obtuse leaves, rather dense

racemes, short pedicels, deflexed in fruit, calyx-lobes scarcely longer than nucules, and deep blackish-brown flowers.

ALKANNA ORIENTALIS, *Linn.*, var. **INTEGRIFOLIA**. Folia integra margine non undulata.

Hab. prope el-Kufr, ditionis Alsadami (vulgo Jebel Qulêb).

Corolla ¾ inch long, ⅜ broad; nucules 1½ line broad.

A. MEGACARPA, *A. DC.*, var. **SHATTUCKIA**. Flores violacei 6–7 lineas lati; indumentum typo mollius.—A very pretty variety. Further study with better specimens may entitle it to specific rank.

TRICHODESMA BOISSIERI. Perenne, totum molliter sericeo-velutinum cinereum superne subpannosum, caulibus ascendentibus superne corymboso-paniculatis, foliis oppositis oblongis vel oblongo-lanceolatis integris acutiusculis, inferioribus in petiolum brevi attenuatis, superioribus sessilibus cordato-amplexicaulibus, racemis paucifloris terminalibus, bracteolis lineari-lanceolatis, pedicellis calyce 2–3plo longioribus demum cernuis, floribus pollicaribus latis, calycis floriferi laciniis lanceolatis acuminatis, corollæ lobis a basi rotundata ovatis acuminatis reflexis, antheris extus parte inferiore breviter cano-pannosis.

Hab. inter ruinas templi Qosr-el-'Abd ad 'Araq-el Amîr, ditionis Moab; floret Aprili et Maio.

Near *T. molle*, DC., but differs from it in more velvety indumentum, longer pedicels, but especially in the short white pannous indumentum of the anthers.

A foot or more high, lower leaves 2½ inches long, 1 broad; the upper gradually diminishing.

PARACARYUM REUTERI, *Boiss. et Haussk.*, var. **LEIOCARPA**. Nuculæ glabræ; stylus fructu sub duplo brevior.

Hab. prope Qaldûn in Damasci planitie; floret Aprili.

XV. SCROPHULARIACEÆ.

VERBASCUM BARBEYI. Bienne, lana detersile pannosum flavidum, caule simplice vel parce ramoso, ramis longis 1–2-pedalibus, foliis radicalibus petiolatis ellipticis magnis crenato-serratis supra sparse stellato pubescentibus caulinis. . . floribus glomeratis spicam longam densam formantibus, pedicellis calyce æquilongis et longioribus, calyce fere ad basin in lacinias lineares acutas partito, corolla flava extus hirta, capsulis calyce brevioribus.

Hab. in cacumine montis Amani supra Hassan Beyley; floret Augusto.

(Sect. II. § 5 *Lychnitidea* **, *Boiss. Fl. Or.* iv. 299), distinguish-

able by its 12–16-inch long 6–8-inch broad lower leaves, and 1–2 dense spikes of yellow flowers.

Plant 3 feet or more high; calyx 2–2½ lines long, corolla 8–10 lines broad; capsule 2 lines long and broad.

VERBASCUM GILEADENSE. Bienne, caule elato adpresse tomentoso superne foliis decurrentibus anguste bialato, foliis radicalibus ad pagum inferius adpresse tomentosis ad pagum superius sparse et adpresse stellato-puberulis oblongis irregulariter inciso-lobatis et dentatis margine valde undulatis versus basin lyratis, caulinis adpresse tomentosis oblongis sessilibus obtusiusculis dentatis, floribus . . . .

Hab. in agris Wadi-es-Sîr, ditionis Gilead; floret Junio.

Readily distinguished from the other Verbascums by its sinuate lower and long decurrent upper leaves, producing a winged stem.

Three feet or more high; root-leaves a foot long, 3–4 inches broad, the upper gradually diminishing. I have not seen a flowering or fruiting specimen.

V. QULEBICUM. Bienne, caule elato crasso superne rigide et ample paniculato plus minusve adpresse tomentoso, foliis radicalibus dense araneoso-pannosis magnis oblongis obtusis basi angustatis grosse crenato-serratis lobatisve sessilibus, intermediis . . . superioribus sessilibus diminutis integris basi rotundatis lanceolatis acuminatis, floribus 2–5 minutis pedicellis calyce longioribus suffultis, calycis fere ad basin fissi laciniis lanceolatis acuminatis, corolla . . . , capsulis piso minoribus ovato-sphæricis calyce longioribus glomerulis fructiferis avellanæ magnitudine.

Hab. in scaturiginibus vulcanicis declivitatis australis montis Alsadami (vulgo Jebel Qulêb) ditionis Haurân.

Readily distinguished from other Verbascums by its cobwebby indumentum, root-leaves 6–15 inches long, 3–5 broad, and panicle a foot long and broad. Plant 3–5 feet high.

CELSIA BERNETI. Bienne, sparse stellato-puberulum vel glabrescens, caule erecto elato fere a basi paniculato ramoso, foliis inferioribus petiolatis caulinis sessilibus oblongo-ovatis obtusis vel acutis crenatis subtus minute porosis, pedicellis filiformibus 1–4 bractea triangulari-lanceolata 2–4 longioribus, calyce hirto in lacinias lanceolatas tubo triplo longiores partito, corolla flava extus glanduloso-hirta, filamentis. . . capsula ovata calyce longiore.

Hab. prope Hadjin in Tauro; floret Maio.

Readily distinguished from *C. heterophylla* by indumentum and entire leaves, with minutely porous lower surface.

Plant 3 feet high; panicle 2 feet long and 1 broad; leaves 2–3 inches long, 1–1½ broad; flowers 8–9 lines broad.

SCROPHULARIA GILEADENSE. Perennis, basi fruticosa glabra vel superne glandulosa, caulibus striatis angulatis flexuosis virgatis superne paniculatis, foliis ambitu oblongis bipinnatisectis segmentis oblongis integris, cymis 3–8-floris pedunculis crassis suffultis, pedicellis calyce et bracteolis subulatis æquilongis vel longioribus, calycis laciniis orbiculatis margine late scariosis, corolla lurido-purpurea magna oblongo-globosa calyce quadruplo longiore sesquilatiore, appendice ovata 1–2-dentata.

Hab. in dumosis inter Sûf et 'Ajlûn, ditionis Gilead.

Readily distinguished from the other plants of Sect. IV. *Tomiophyllum*, § 2. *Sparsifolia*, by the large inflated corolla, 3 lines long, 2½ broad.

Plant 1½ foot high; leaves 1–1½ inch long, 3–4 lines broad, segments 1½–3 lines long.

XVI. LABIATÆ.

THYMUS SYRIACUS, *Boiss.*, var. **TRACHONITICUS.** Caules humiles suffruticosi tortuosi, capitulæ pauciflora, bractei anguste ovato-oblongi, flores parvas occultanti.

Hab. in fissuris lavæ prope Braq, ditionis Trachonitis (vulgo el-Leja); floret Maio.

SALVIA PURPURASCENS. Perennis, caule glabro superne purpurascenti elato simplici, foliis petiolatis imparipinnatis 1-jugis petiolis sparse infra et ad margines pilosis, foliolis supra glabris infra sparsissime papillosis ovatis crenatis vel obtuse dentatis terminale cæteris 2½plo longiore et latiore basi cordato inferioribus obtusis superioribus acutis, verticillastris 4–3-floris distantibus racemosis, foliis floralibus ovato-lanceolatis acuminatis calyce æquantibus vel superantibus glabris margine ciliatis, pedicellis calyce subduplo brevioribus, calycis parce papillosi ad quartam partem bilabiati dentibus anguste triangularibus acuminatis subpungentibus, corolla cærulescenti calyce vix sesquilongiore.

Hab. inter Marash et Adana; floret Maio.

Nearest to *S. rubifolia*, Boiss., but distinguished from it by glabrescence, purplish colour, large bracts, larger flowers, and more exserted corolla.

Plant 2 feet high, bracts 5–9 lines long.

Nepeta trachonitica. Perennis, puberula canescens, caulibus elatis inferne parce ramosis quadrangulatis valde costatis canaliculatis, foliis inferioribus longe petiolatis cordato-ovatis obtuse et grosse serratis, superioribus breviter petiolatis subsessilibus oblongo-ovatis acute et grosse serratis, spica densa oblonga basi vix interrupta, bracteis tomentosis lineari-subulatis calyce dimidio brevioribus, calycis rubelli-viridis dentibus tubo oblongo basi attenuato duplo brevioribus basi latiore subulatis pungentibus, corollæ roseæ tomentosæ tubo gracili recto calyce parum longiore, nuculis valde tuberculatis.

Hab. inter ruinas Shuhbah ditionis Trachonitis (vulgo el-Leja).

Near *N. betonicæfolia*, C. A. Mey., but distinguished from it by indument, larger and more compact heads, and coarsely serrate not crenate leaves.

Plant 2–3 feet high; leaves 1½–2 inches long, 10–15 lines broad; heads 1½–2 inches long, an inch broad; calyx 7 lines long.

N. Shepardi. Perennis, adpressissime velutina cana basi suffruticens, caulibus numerosis simplicibus vel basi ramosis rigidis, foliis parvis breviter petiolatis triangulari-ovatis obtusis integris floralibus valde diminutis, cymulis oppositis breviter pedunculatis distantibus, calycis cinerei ore recto dentibus breviter ovatis apice abrupte calloso tubo triplo brevioribus, corollæ pallidæ dense tomentellæ tubo calyce subduplo longiore, labio inferiore purpureo maculato, nuculis....

Hab. prope Aintab.

Differs from *N. marifolia* in indumentum, in smaller size of ovate entire, not oblong crenate leaves, in much smaller flowers, greyish calyx with short obtuse teeth.

Plant 1 foot high; leaves 5–2 lines long; calyx 2 lines long.

Sideritis montana, *Linn.*, var. **xanthostegia.** Ad caules patule ad verticillastra dense villosa nec non lanata, calycis flavidi valde venosi dentes aristati, bracteæ flavescentes, racemi turione foliorum flavorum terminati.

Hab. prope Amasia, Asiæ Minoris.

Stachys libanotica, *Benth.*, var. **eriocalycina.** Calyx albolanatus, dentes eis typi basi angustiores.

Hab. ad viam inter Suédah et 'Atîl ditionis Haurân.

Phlomis fruticosa, *L.*, var. **leiostegia.** Perennis. Indumentum eo typi strigosius, bracteæ glabrescentes parce stellatostrigulosæ penninerveæ abrupte in mucrones longos attenuatæ, calyx parce strigosus dentes eis typi longiores.

Hab. in vallibus calidis inter Ma'în et Callirrhoë ditionis Moab.

Teucrium auraniticum. Perenne, dumosum, crispe papilloso-puberulum superne canescens, caudice ligneo, ramis numerosis flexuosis rigidis fere a basi paniculatim ramosis, foliis pallide viridibus breviter petiolatis ovato-oblongis obtusis obsolete dentatis, floralibus oblongo-lenticulis integris valde diminutis flores superantibus, cymis longe pedunculatis cymulis pedicellatis 2–3-floribus bracteis linearibus hirtis, calycis minuti hirti fructiferi valde accreti dentibus breviter triangularibus obtusis, corolla alba hirta calyce subduplo longiore, staminibus inclusis.

Hab. in agris ditionis Auranitis (vulgo Haurân); floret Maio.

Readily distinguished by puberulent indumentum, few-flowered proliferous cymes of small sessile flowers, in pedicelled cymules.

XVII. PLANTAGINACEÆ.

Plantago ovata, *Forsk.*, var. lanata. Folia augustissima, axis dense lanuginosa.

Hab. in agro ditionis Auranitis (vulgo Haurân) inter Irbid et Bosrah; floret Maio.

XVIII. LILIACEÆ.

Bellevalia ciliata, *Cyr.*, var. paniculata. Elata plus minusve paniculata 2–3-pedalis, pedunculi 5–6 pollices longi, foliorum margines non ciliati.

Hab. prope a Husn Suleimân, montibus Nusairîyah, Syriæ borealis.

XIX. ASPARAGEÆ.

Asparagus Lownei, *Baker*, var. calcaratus. Folia basi calcarata.

Hab. ad pontem novum Jordanis.

XX. GRAMINEÆ.

Alopecurus involucratus. Perennis, radice præmorsa fibros edente, culmis geniculatis decumbentibus scabriusculis, foliis linearibus minute scabridulis vaginis inferioribus cylindricis superioribus utriculoso-inflatis, pedunculo clavato superne in involucrum glabrum scariosum cyathiforme parallele nervosum panicula ovata vel oblonga triplo brevius explanato, ramis 1-

spiculatis, glumis scariosis fere ad medium connatis ad carinas eximie et secus nervos minute ciliatis oblongis mucronatis, glumella glumis breviore obtusa fere ad basin aristata, arista glumis duplo longiore.

Hab. in humidis inter Qurêyah et El-Kufr ditionis Auranitis (Haurân) ad basin Jebel-Qulêb (Alsadami).

A plant with aspect of *A. utriculatus*, but immediately distinguishable by its involucre. The species is intermediate between *Alopecurus* and *Cornucopiæ*.

Culms 6 inches high ; panicles 6–9 lines long, 4–5 broad.

On the Scars occurring on the Stem of *Dammara robusta*, C. Moore. By SAMUEL G. SHATTOCK. (Communicated, with a Supplementary Note, by W. T. THISELTON DYER, C.M.G., M.A., F.R.S., &c.)

[Read 3rd November, 1887.]

(PLATE XVII.)

SOME time ago the stem of a specimen of *Dammara robusta* grown in the Royal Gardens, Kew, was placed in my hands by Mr. Thiselton Dyer, with the object of describing and figuring the scars which occur on the trunk of this conifer, partly on account of the intrinsic interest attaching to the disarticulation of branches generally, partly because similar scars may perhaps be found on fossil forms, and it is in some measure by a study of existing scars that the significance of those occurring in fossil or in extinct forms can be elucidated.

Schimper in his work on fossil plants, 'Traité de paléontologie végétale' (vol. ii. p. 255), includes two forms of *Dammarites*, diagnosed, however, only by the cones ; these forms are met with only in the Cretaceous Epoch and after the complete disappearance of Lepidodendroid trees ; and he includes also, on the authority of Saporta*, *Populus tremula*, and species of Oak (which present similar branch-scars); these, diagnosed by leaf-remains, occur, however, at no more distant period than the Pliocene, when Dicotyledons are largely represented.

The importance of every mark among the scanty data usually forthcoming in determining the habit or class of fossil trees may serve as an apology, therefore, for the present notice of *Dammara robusta*.

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* 'Le monde des Plantes avant l'apparition de l'homme.' 1879.

The foliage in *Dammara robusta* is confined to the neighbourhood of the summit of the erect, undivided stem. The branches are given off in pseudo-whorls of five, with a slight upward obliquity or at a right angle, and they are usually confined in old individuals to the upper part of the tree. The branches are shed in succession from below during the upward growth of the tree, and the resulting scars persist on the stem, even to its lowest part.

The general surface of the stem bears the sparsely scattered scars of fallen leaves, and the younger portions of the stem are strewn with lenticels.

The scars, both branch and leaf, follow the general law of scar-growth; that is, they grow commensurately with the part on which they are seated.

The formation of the branch-scars in *Dammara*, as in the few other trees in which the branches are articulate, is altogether different from the scarring that occurs under ordinary conditions after the removal of a woody branch.

Amongst the few trees which permit of branch-disarticulation may be mentioned, among Angiosperms, *Populus tremula*, some kinds of Willow, *Quercus Robur*, *Antiaris toxicaria*, **Castilloa elastica*; among Gymnosperms, an articulate disposition obtains in Gnetaceæ; and in *Taxodium distichum* the axes that bear leaves are deciduous (Sachs, Textbook, 2nd Engl. ed. p. 511).

But in the vast majority of trees no provision for the disarticulation of branches exists. In very young branches, dying internodes may be cleanly detached; but this occurs only before the permanent tissue of the wood is formed, and is effected by transverse subdivision of the elements of the whole of the ground tissue and procambium across the zone of demarcation, the middle cells of the zone becoming suberous. This process may readily be observed if a young branch of the Lime, for example, be divided through the distal end of an internode; under these circumstances the whole of the internode is subsequently cleanly shed, sometimes after having undergone very little outward change; the process that ensues is strictly like that which accompanies the disarticulation of a leaf.

With such an exception, the dead wood of a dead branch retains its connection with that of the parent stem until it is rendered so brittle and friable by decay, by the thinning and partial removal of the woody prosenchyma, that fracture ensues by its own weight, or from the first slight violence that befalls it. Long before this occurs, the cortical parenchyma of the dead part is completely demarcated from that of the living; this is effected by transverse division of the parenchymatous cells and the formation of an intervening plane of cork. In this process, also, the cambium readily participates, its cells undergoing transverse subdivision to produce phellogen and cork,—it plays the part of a cork cambium under the altered relations of the parts, as readily as it before served for the production of wood and bast. After the complete detachment of the dead part, a ring of cork-covered callus advances from the cambium over the fractured surface of the dead wood, and ultimately covers it completely in, though the new tissue, which becomes differentiated into wood and an external cortical system, contracts no adhesion with the dead surface.

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* See Note on the Disarticulation of Branches, by R. Irwin Lynch: Journ. Linn. Soc. vol. xvi. pp. 180–183.

This short account may suffice to contrast these cases with those in which branches are detached by disarticulation. No structural provision exists in the one case whereby a dead part may be detached; the provision which allows of disarticulation in the other case differs slightly in different examples.

In *Dammara robusta* a longitudinal section (Pl. XVII. figs. 1, 2) displays at once the means by which this ready separation or disarticulation is allowed. The base of the branch presents a marked enlargement, due almost solely to an increase of the cortical parenchyma; this excess serves to supplement the wood, in this situation, in supporting the branch; the cortical parenchyma generally and the medulla as well contain a considerable proportion of branching sclerenchymatous idioblasts. As regards the wood, the section displays an extreme thinning of this in the base of the branch; that is to say, where the wood of the branch is continued into that of the stem.

This disproportionate tenuity of the wood is demonstrable also in transverse sections, by means of which it appears that, associated with the retardation of woody growth in this situation, the primitive condition, in which the fibro-vascular bundles are dissociated, is scarcely passed. This primitive disposition of the wood at the base of the branch and the associated undue proportion of parenchyma is especially well seen at the branch-junctions in *Populus tremula*, where on stripping off the cortex, after drying, a series of deep longitudinal clefts is disclosed in the area through which disarticulation takes place.

In *Dammara robusta* it is in this weakened zone that the plane of disarticulation lies. The process resembles in its details that by which deciduous leaves or other caducous organs are shed. If the base of the shed branch be examined by means of longitudinal sections, it will be seen that the cortical parenchyma is bounded at the detached surface by muriform sclerenchymatous cells in two or more rows, and on these are the remains of cork-cells; the same is seen in the largely proportioned medulla, where there is a more distinct phellogen beneath the sclerenchyma; the bast parenchyma and cells of the medullary rays present similar changes.

Longitudinal sections of the young scar on the stem show the cicatrix to be constituted by flattened cells of cork set in parallel tiers and a subjacent phellogen of similar form; the fractured wood will be found covered in, in like manner, with cork and phellogen.

In the older scars sclerenchyma may be found alternating with layers of cork: the sclerenchymatous cells are muriform like those of the cork amongst which they lie, and they are clearly produced periodically from the subjacent phellogen, their original connection with which is subsequently lost by a fresh formation of cork beneath them.

From these appearances it may be gathered that the process of disarticulation is like that by which a leaf or other organ is shed; that is, the parenchymatous cells across the whole zone of articulation multiply by transverse division, a layer of cork resulting from the formation of this secondary meristem, and through the distal limits of this the solution of continuity occurs; after this the slender connecting bond of wood is broken across by the weight of the branch or the first trivial violence, this completion of the process being aided, perhaps, by the tension made upon the wood in consequence of the cell-division of the surrounding parenchyma which occurs across its axis. It thus happens that the whole of the parenchymatous system of the stem is closed by cork *before* the branch is actually shed.

The purpose served by such a systematic disarticulation is difficult to perceive. I have elsewhere suggested that in all such cases the process represents, or is an evolutionary relic of, a bygone means of asexual propagation. Certainly, in the case of the articulate stems of *Crassula arborescens*, the separation of parts is at times followed by root-formation from the pieces so shed and their subsequent growth; and it is possible, even, that the ordinary fall of leaves has a similar evolutionary history.

In *Cotyledon Hookerii* I have often seen the fallen leaves serve as adventitious organs of propagation; and the same is true of *Bryophyllum*, whilst the striking of detached Orange and *Begonia* leaves is a well-known phenomenon. Mr. Thiselton Dyer tells me that the branches torn off by the wind or by accident from the arboreal Aloe of Caffraria (*A. Barberæ*) are said to take root.

The branch-scar, when examined immediately after disarticulation, is ovoidal, concave, and has a finely granular surface; the narrow circular zone of the fractured wood projects slightly at the bottom of the cicatricial fossa, and in the cortical parenchyma are embedded the ruptured ends of the bast-fibres.

In the subsequent history of the scar, as traceable by dissection*, the fractured surface of the wood becomes covered over and closed in by a thin extension of the surrounding parenchyma, a low oval or horseshoe-shaped ridge remaining on the cicatricial surface to mark the situation of the closely subjacent fractured wood. At the same time the surface of the scar becomes smooth and shining from the further growth of its investing corky layer; and this may, in process of time, fissure like that which covers the general surface. The remains of the wood and bast-fibres passing through the parenchymatous system of the scar permanently retain their position in and connection with the superficial parts of the scar.

No further growth, however, of this wood and bast in the mid-substance of the ground-tissue of the scar occurs; and the addition of wood to the general surface of the stem has the remarkable effect of rupturing or dissociating this wood in the scar from the wood of the stem with which it was originally related. In the history of a leaf-scar the same thing happens; that is to say, on the accession of general growth, the remains of the closed bundles of the petiole, in what has now become, by the separation of the leaf, a part of the general cortex, retain their connection, the more superficial parts with the tissue of the scar, the deeper with the central wood and medullary sheath, with which they are primarily related: the bundles are ruptured by the tension of the general cambium-growth; and in microscopical sections the two portions are easily recognizable in these two situations, beneath the cork of the scar, and buried in the deepest part of the wood; and this is true however widely separated the two portions may be by the annual additions of wood to the general surface of the branch*. In the leaf-scar still another rupture of the fibro-vascular bundles is to be observed; the addition to the deeper part of the cork of the scar effects a rupture of the bundles in this situation; and remains of these are to be detected in the boss of cork which marks their situation in the scar separated by the deeper and subsequently formed layers of cork from the ends of the bundles in the subjacent ground-tissue.

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* I have presented a series of preparations illustrating this history to the Museum of the Royal Gardens, Kew.

Each yearly addition of wood to the stem in the case of the branch-scars of *Dammara* serves to increase by so much further the interval between the woody relics of the shed branch in the parenchyma of the scar and the central medulla. In longitudinal sections, however, the point of origin of the shed branch from the deepest part of the wood remains easily discernible, however great the additions made to the general surface of the wood may have been. In the later history of the scar, wood is formed in the central parenchyma; that is, in what before disarticulation was continuous with the medulla of the branch. This doubtless occurs, as in similar cases, by the formation of secondary wood-forming meristem from the indifferent parenchyma or ground-tissue. A complete screen of wood is before long formed. This increases in thickness commensurately with the stem, although the wood produced from the medullary parenchyma of the scar is not in the arrangement of its elements uniform with that around, but forms an almost distinct system. In longitudinal sections of old scars this wood appears as a cylindrical process or core, connected, it may be, but little with the general wood around, the cells and vessels of which arch round on either of its sides. On removing the cortex from a scar of old date, a deep central fossa is exposed, the bottom of which corresponds with this woody core. The depression in the wood is filled in by a corresponding process of cortical parenchyma and bast-fibres, the latter forming a tortuous complex heap appertaining to the woody system of the core, and, like it, arranged independently of the general phloëm. The cambium elements of the scar, therefore, it is clear, are not arranged in conformity with those of the rest of the stem. The cicatrix resulting from the common detachment of a dead branch in an exogenous tree and that resulting from disarticulation are readily distinguishable. In the first case healing is effected by a growth of callus from the surrounding cambium which extends over the fractured surface of the wood; in the callus are differentiated a superficial cortical system and a deep system of modified wood. The most central part of the scar in such cases presents an external eminence which marks the central meeting and coalescence of the circular cicatricial growth from the margin.

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* The bast-fibres passing to the scar, however, are not involved in the rupture, since the general bast is displaced outwards equally with that of the scar in the subsequent process of growth.

After branch-disarticulation or cladoptosis (Berkeley), the surface heals throughout simultaneously, or, more truly, it is healed before the branch is actually shed; and the scar in this case, in place of being centrally convex, is concave throughout.

Do the branch-scars in *Dammara*, Aspen, Oak, &c. throw any light on the scars occurring in *Ulodendron*, the nature of which has been the subject of so much discussion? I am afraid not. Indeed, when it is considered how different is the histology of the extinct Lycopods from that of any existing trees, it is almost hopeless to expect to find any existing scars identical with those of *Ulodendron*.

In *Ulodendron* the scar, as Carruthers remarks, is always in the form of an inverted cone, generally, however, flattened from the enormous pressure, and more or less oval; the base or centre of the pit is different in different species, double horseshoe-shaped, half-oval, or circular: the figure is formed by a number of small pits representing the number and position of the vascular cords which supplied the supported organ; the remainder of the scar is covered with single pits or radiating furrows arranged in symmetrical order around the base of the scar, the pits being confined to the lower half of the scar, the furrows to the upper half. In *Dammara* the scar presents a central fossa, of different depth in different scars, and this is bounded by a low oval or horseshoe-shaped ridge which marks the situation of the fractured wood, beyond which is a lowly convex ring, corresponding with the cortical parenchyma of the shed branch.

That the appendicular organs, whatever they were (and every conceivable supposition as to their nature has been made), were caducous appears certain from the fact that the scars are in all cases completely formed, and no remnants of the separated organ persist in connection with them. And it may be assumed that the disarticulation proceeded from below upwards; the great size of the scars points to this. For it is a fact of some importance, and which I have not found noticed, that the size of the scars by no means necessarily represents the actual area of the separated surface of the disarticulated organ, since the scars, as in other exogenously growing trees, must have grown commensurately with the part on which they were seated. This may be readily observed in the case of ordinary leaf-scars. In *Æsculus Hippocastanum*, for example, the leaf-scars come in the older branches to exceed beyond all bounds their original size; the seven corky points, indicating the position of the subjacent ruptured fibro-vascular bundles, retain their relative, but not their original, distances from one another and from the margin of the scar.

The pits and furrows on the scars of *Ulodendron*, as was shown by Presl and Goppert, are the ends of fibro-vascular bundles; and these authors regarded the scars as those of branches. This is also the view taken by Renault ('Cours de Botanique fossile,' 1880), who, however, places as an alternative that the scars may be those of the fructification, the strobiles or lepidostrobi.

Carruthers's view that the scars result from the separation of aerial roots* (or, as now regarded, rhizophores) is based on the fact that in one instance described by him the scars have a downward inclination, as proved by the opposite direction of the remains of the leaves.

Among living forms of plants the scars of aerial roots are by no means easy to find.

I have examined *Philodendron*, *Vanilla*, and different Orchidaceæ, but in none have I ever seen a perfectly formed scar; the roots that die are not shed, but, with the greatest tenacity, remain connected with the rest of the plant. The central fibro-vascular system of the dead root projects from the centre of the scar after all the surrounding parenchyma has been removed by decay, and the surface subjacent to the latter has been smoothly healed by cork-formation.

In *Philodendron* the cortical parenchyma of the roots generally heals by layers of tabular cork-cells produced by a subjacent phellogen, which is formed by subdivision of the cells of the ground-tissue: this may be observed if the ends of roots be cut off, in which case an offset grows from the side above the divided healing surface. But in addition to this there is produced, after a while, a regular zone of sclerenchyma as an adjunct in the repair.

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* Monthly Microscopical Journal, March 1, 1870, p. 150.

The sclerenchyma is of more or less flattened muriform cells, which sometimes are many layers deep, formed from the phellogen beneath the earlier cork-formation; and as cork is again produced from the phellogen beneath the sclerenchyma, the latter comes at length to lie in the midst of the corky covering of the cicatrized surface. Such sclerenchyma I have observed also to be formed from the reparative phellogen in many *Cactaceæ*, *Cereus*, *Opuntia*, &c.; and it may be found also in the cork that repairs the old leaf-scars in *Aucuba*.

The fact is of a little present interest, since Carruthers describes the rhomboidal leaf-scars in the fossil form *Lepidodendron selaginoides* as showing that healing had occurred by the production of a "layer of small thickened cells;" * and in the older scars of *Dammara*, as before described, flattened sclerenchyma is found in the substance of the cork.

[Note.—The author has perhaps scarcely laid sufficient stress on the distinctive characters of the structures which in many species of *Selaginella* give origin to the roots, and which Nägeli named Rhizophores. These "arise very near the *punctum vegetationis*, probably at the same time as the branches; unlike the roots, they are exogenous structures which, when young, possess a distinct apical cell." From these rhizophores "the first rudiments of the true roots originate, which, however, do not break through until the rhizophore has attained such a length by intercalary growth, that its smaller end penetrates into the ground. The rhizophores, as Pfeffer has shown (in *S. Martensii*, *inæqualifolia*, and *lævigata*), are often transformed into true leafy shoots, which at first show some deviations from the normal structure in their leaves, but afterwards continue to grow as normal shoots, and even produce sporangiferous spikes." (Sachs, 'Textbook,' 2nd Engl. ed. pp. 477, 478.)

The author remarks that though the number of cases in which branches suffer disarticulation in the manner of leaves is now somewhat numerous, it is difficult to find parallels in the case of aerial roots. It occurs to me that this may be connected with the fact that the mode of origin of the former is exogenous, that of the latter endogenous. Rhizophores, however, in this respect resemble branches. While it appears to me as incontestable that the scars of *Ulodendron* were due to the disarticulation of axial organs of some kind, there is nothing, I think, improbable in the suggestion that they may have belonged to rhizophores; and the view is, at any rate, one which is worth consideration.—W. T. THISELTON DYER.]

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* **Monthly Microscopical Journal, Oct. 1, 1869, p. 181.**

DESCRIPTION OF PLATE XVII.

Anatomy of Leaf-scars.

Figs. 1, 2. Section of *Dammara robusta*, at the junction of branch and stem.
Figs. 5, 6. The same.
Fig. 7. Exterior view of scar of *Dammara*, from which a branch has fallen.
Fig. 3. Leaf-articulation of Horse-Chestnut (*Æsculus Hippocastanum*) showing course of fibro-vascular bundle.
Fig. 4. Old leaf-scar in same, showing rupture of the fibro-vascular bundle by the cambial growth of the wood.

A Description of three new Marine Algæ.

By EDWARD A. L. BATTERS, B.A., LL.B., F.L.S.

[Read 15th March, 1888.]

(PLATE XVIII.)

ECTOCARPUS HOLMESII. (Plate XVIII. figs. 7–16.)

E. cæspitosus, thallo ½–1 cm. alto, filis parce ramosis, implexis, ramulis brevissimis secundis curvulis, sub angulo recto vel fere recto egredientibus, articulis 1½–2 diametro longioribus, sporangiis subsessilibus vel plus minusve pedicellatis, latere ramorum secundis, unilocularibus, sphæricis vel ovatis, circiter 62 μ longis, 48 μ crassis, multilocularibus, ovato-conicis, 230 μ longis, 44 μ crassis.

Hab. Torquay, Minehead, Berwick-on-Tweed.

A small species seldom more than a quarter of an inch in height. It covers the rocks for a considerable distance with a soft brown turf, the patches often being four or five feet in diameter. The filaments are so short that it is almost impossible to detach them from the rock without the aid of a knife or similar instrument. At Minehead it grows on woodwork; but Mr. Holmes tells me he found it growing on ledges of rock, in the shade at Torquay, near high-water mark; and at Berwick I found it growing on the walls of caves and the perpendicular sides of rocks and stones, also near high-water mark.

In the summer of 1884 my friend Mr. E. M. Holmes called my attention to this curious little alga, which, having received similar specimens from Minehead under the name of *Ectocarpus crinitus*, Carm., he had supposed to be Harvey's plant, not having then seen authentic specimens. I was doubtful about the plant being identical with Harvey's; but until I had examined authentic specimens of *Ectocarpus crinitus*, I could form no accurate judgment as to whether it were so or not. Lately, however, by means of a series of the plant collected at Torquay by Mr. Holmes, and of other specimens, including an authentic one of *Ectocarpus crinitus*, which he has since put at my disposal, I have ascertained that my doubts were well founded.

E. crinitus, although agreeing fairly well with my *E. Holmesii* in ramification, is in every respect a larger and coarser plant, its filaments are nearly twice as thick, its articulations are longer, and its habit and colour quite different. *E. Holmesii* seldom attains a greater length than a quarter of an inch, and is almost always found in fruit, whereas *E. crinitus* is often many inches long, and all the British specimens I have seen are barren. Dr. F. Hauck, however, has sent me specimens from Trieste under the name of *E. crinitus* which are well-fruited.

As the plant was unknown to all the Continental algologists to whom I sent it, and as it appears equally unknown in America, I have ventured to describe it as new, and have dedicated the species to Mr. Holmes, whose untiring industry in the investigation of the marine flora of our islands, and the many valuable additions he has made to our knowledge of British marine algæ, are known to all algologists.

PHYLLITIS FILIFORMIS. (Plate XVIII. figs. 1–6.)

P. thallo circiter 1–2 cm. alto, angustissimo lineari vel filiformi, e radice fibrata egrediente, olivacea, ætate flavescente, sporangiis multilocularibus, circiter 37 μ longis, 7 μ crassis.

Sporangia habet *P. Fasciæ*, frondes vero multo angustiores et radices fibratas.

Hab. Berwick-on-Tweed.

This little plant grows at high-water mark in company with *Ulothrix flacca*, *Calothrix Scopulorum*, and other high-water species. When young the fronds are olive-brown, but in age they turn yellowish, and then the plant looks more like an *Ectocarpus* than a *Phyllitis*. The fructification is produced on fronds scarcely thicker than a hog's bristle. In structure and fructification this plant agrees with *Phyllitis Fascia*, from which it can at all times be distinguished by its small size and fibrous root. It seems to be a winter annual, making its appearance about the middle of December, and having quite disappeared by the end of February.

RALFSIA SPONGIOCARPA. (Plate XVIII. figs. 17–21.)

R. nigrescenti-olivacea, tenuis, lævis, tota pagina inferiore lapidibus adnata, filis erectis simplicibus (vel parce dichotomis) articulatis, articulis 1–1½ diametro brevioribus, paranematibus subcylindraceis, vel superiore parte paulatim attenuatis, sporangiis unilocularibus, ovatis, sessilibus vel plus minusve pedicellatis, 48–52 μ longis, 28 μ crassis.

Hab. Berwick-on-Tweed.

An interesting plant growing on the flat slaty bottoms of tide-pools half filled with sand at Berwick. To the naked eye it closely resembles *Ralfsia clavata*, Crouan, but the frond is thinner, and the fructification much more conspicuous, the difference in colour between the fruited and unfruited portions of the frond being very apparent. The fronds are from a quarter of an inch to an inch in diameter, very thin, and when barren perfectly smooth and glossy, circular at first, then, from several becoming confluent, more or less lobed or irregular. The sori, at first confined to a narrow ring near the margin of the frond, gradually spread inwards until they cover the entire central portion of the frond, giving to it a peculiarly spongy or velvety appearance under a lens, a characteristic which suggested the specific name. The fruited portion of the frond soon becomes detached from the stone, and is washed away, leaving only the marginal portion of the plant. As this alga fruits in winter, only the very small unfruited portions of the plant are to be found in summer; this, coupled with the fact that the pools in which it grows are often quite filled with sand, may account for the plant having been so long overlooked.

From *Ralfsia clavata* it differs in the shape of the paraphyses, which are always cylindrical or slightly tapering to the apex, never clavate as in that species. The vertical filaments, which sometimes appear to be slightly branched, gradually pass into the paraphyses, and there is never any clearly marked line of separation between them as in *R. clavata*. When fresh the sori of both species are fleshy, and slightly raised above the surface of the frond, but when allowed to dry they shrink considerably more than the rest of the plant, which causes them to crack all over; but as both species, so far as I have observed, grow under water, this can very seldom happen naturally. I am indebted to Prof. Farlow, of Harvard College, for American specimens of *R. clavata*, and also for valuable notes on the affinity of the species.

Even the genus to which this interesting alga belongs appears doubtful. Dr. Bornet and Prof. Agardh consider it a true *Ralfsia*, but, on the other hand, Dr. Kjellman thinks it is more nearly related to *Lithoderma* or *Stragularia*, and Dr. Hauck would place it and *Myrionema Henschii* in a new genus.

The sporangia are usually attached at the base of the paraphyses, but not unfrequently they appear to be terminal on the vertical filaments (see Pl. XVII. fig. 21), as in *Lithoderma*, calling to mind the passage in Areschoug's description of that genus, where he says: "Utraque fructificatio, in diversis plantis, filisque verticalibus quorum cellulæ apicales longe sunt productæ, circumdata." It thus forms a link between the *Ralfsiaceæ* and *Lithodermaceæ*.

EXPLANATION OF PLATE XVIII.

Phyllitis filiformis, figs. 1–6.

Fig. 1. Plant, natural size. Figs. 2, 3. Roots, × 300. Fig. 4. Portion of frond with plurilocular sporangia, × 300. Fig. 5. Section of frond, × 300. Fig. 6. The same, × 600.

Ectocarpus Holmesii, figs. 7–16.

Fig. 7. Plant, natural size. Fig. 8. The same, from Minehead, × 150. Figs. 9–12. Specimens of plurilocular sporangia, × 600. Figs. 13–15. Unilocular sporangia, × 600. Fig. 16. Distorted cell, × 600.

Ralfsia spongiocarpa, figs. 17–21.

Figs. 17, 18. Plant, natural size, *in situ*. Fig. 19. Sporangium and paraphysis, × 600. Fig. 20. Branching vertical filament, × 600. Fig. 21. Terminal sporangium, × 600.

Ralfsia clavata, Crouan, fig. 22.

Fig. 22. Sporangium and paraphysis, × 600; for comparison with the foregoing.

On the Flora of Water-Meadows, with Notes on the Species.

By W. Fream, B.Sc., LL.D., F.L.S., F.G.S., Professor of Natural History, College of Agriculture, Downton, Salisbury.

[Read 19th April, 1888.]

Water-meadows are a conspicuous feature in the rural economy of the West of England. They are usually adjacent to the banks of rivers, and they are irrigated with river-water periodically. But though they are frequently submerged, the water in contact with them is running-water and well aerated, so that the herbage is in many respects different from that associated with stagnant water. The regular "flooding" or "drowning" of the meadows renders them, to a great extent, independent of the season, so far as rainfall is concerned; and when all the circumstances connected with water-meadows are taken into account, it is seen that the herbage they carry grows under conditions which, for uniformity, are seldom equalled. They therefore offer a favourable means for the study of meadow-herbage grown under long-continued uniformity of conditions, and it was this circumstance that, in the first place, led me to take up the subject. The particular water-meadows I have had under observation for some years are on the western bank of the Hampshire Avon, at North Charford, in South Hants, but close to the border of South Wilts, about eight miles due south of Salisbury, about four miles from the Dorset border, and on the north-western confines of the New Forest. The soil is a clayey loam (alluvium), with flints, resting on the Upper Chalk.

Following the method adopted by Lawes, Gilbert, and Masters *, it will be convenient to arrange the flowering plants under the three heads of Gramineæ, Leguminosæ, and Miscellaneous Species or weeds. The following are the species of flowering-plants, 85 in number, which I have found upon these water-meadows.

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* "Agricultural, Botanical, and Chemical Results of Experiments on the Mixed Herbage of Permanent Meadow, conducted for more than twenty years in succession on the same Land.—Part II. The Botanical Results." By Sir J. B. Lawes, Bart., LL.D., F.R.S., F.C.S., J. H. Gilbert, Ph.D., F.R.S., F.C.S. F.L.S., and M. T. Masters, M.D., F.R.S., F.L.S. Phil. Trans. Part IV. 1882.

Gramineæ (26).

Phalaris arundinacea, *L.*
*Anthoxanthum odoratum, *L.*
Alopecurus geniculatus, *L.*
—— pratensis, *L.*
*Phleum pratense, *L.*
Agrostis alba, *L.*
*—— vulgaris, *With.*
*Aira cæspitosa, *L.* (Deschampsia cæspitosa, *Beauv.*).
*Holcus lanatus, *L.*
*Avena flavescens, *L.* (Trisetum flavescens, *Beauv.*).
*—— elatior, *L.* (Arrhenatherum avenaceum, *Beauv.*).
Phragmites communis, *Trin.*
*Cynosurus cristatus, *L.*
*Briza media, *L.*
Poa annua, *L.*
*—— trivialis, *L.*
*—— pratensis, *L.*
Glyceria aquatica, *Sm.*
—— fluitans, *R. Br.*, et var.
Festuca duriuscula, *L.*
—— elatior, *L.*
*—— pratensis, *Huds.*
—— loliacea, *Huds.*
Bromus racemosus, *L.*
*—— mollis, *L.*
Lolium perenne, *L.*

Leguminosæ (7).

*Medicago lupulina, *L.*
*Trifolium pratense, *L.*
*—— repens, *L.*
*Lotus corniculatus, *L.*
*Lotus major, *Scop.*
*Vicia Cracca, *L.*
*Lathyrus pratensis, *L.*

Miscellaneous Species (52).

Ranunculaceæ.

Thalictrum flavum, *L.*
*Ranunculus acris, *L.*
*Ranunculus bulbosus, *L.*
Caltha palustris, *L.*

Cruciferæ.

*Cardamine pratensis, *L.*

Caryophyllaceæ.

Lychnis Flos-cuculi, *L.*
*Cerastium triviale, *Link.*

Linaceæ.

Linum catharticum, *L.*

Rosaceæ.

*Spiræa Ulmaria, *L.*
Geum rivale, *L.*
*Potentilla reptans, *L.*
—— Anserina, *L.*

Lythraceæ.

Lythrum Salicaria, *L.*

Onagraceæ.

Epilobium hirsutum, *L.*
—— parviflorum, *Schreb.*
Epilobium tetragonum, *L.*

Umbelliferæ.

*Heracleum Sphondylium, *L.*

Rubiaceæ.

Galium palustre, *L.*

Valerianaceæ.

Valeriana dioica, _L._
Valeriana officinalis, _L._

Compositæ.

Eupatorium cannabinum, _L._
*Bellis perennis, _L._
*Achillea Millefolium, _L._
*Chrysanthemum Leucanthemum, _L._
Senecio aquaticus, _Huds._
Carduus palustris, _L._
*Leontodon hispidus, _L._
*—— autumnalis, _L._
*Taraxacum officinale, _Web._

Primulaceæ.

Lysimachia Nummularia, _L._

Boragineæ.

Symphytum officinale, _L._
Myosotis palustris, _With._

Scrophularineæ.

Scrophularia aquatica, _L._
*Veronica Chamædrys, _L._
—— scutellata, _L._
Veronica Anagallis, _L._
—— Beccabunga, _L._

Labiatæ.

*Thymus Serpyllum, _L._
Scutellaria galericulata, _L._
*Prunella vulgaris, _L._
*Ajuga reptans, _L._

Plantagineæ.

Plantago major, _L._
*Plantago lanceolata, _L._

Polygonaceæ.

Polygonum Persicaria, _L._
*Rumex crispus, _L._
Rumex aquaticus, _L._
*—— Acetosa, _L._

Urticaceæ.

Urtica dioica, _L._

Juncaceæ.

Juncus glaucus, _Ehrh._
Juncus acutiflorus, _Ehrh._

Cyperaceæ.

Eleocharis palustris, _R. Br._
Carex paludosa, _Good._

The foregoing lists may be usefully compared with the corresponding lists given by Lawes, Gilbert, and Masters in the classical investigation already referred to. Their observations were carried out upon grass-land, probably some centuries old, at Rothamsted Park, Hertfordshire; the land is described as a somewhat heavy loam, with a red clay subsoil resting upon chalk; and though it is not artificially, it is thus naturally well drained. Although the plots of meadow-land at Rothamsted were subjected to twenty continuously different kinds of manuring, a comparison of the entire flora there with that at North Charford should reveal some interesting features concerning the nature of the herbage grown in dry and water-meadows respectively, and might serve to bring out more prominently the distinctive characters of the latter. To avoid repetition, I have marked with an asterisk (*) in the foregoing lists all the species which occur at Rothamsted; those not so distinguished are found only on the water-meadows.

In the following lists, on the other hand, are enumerated those additional species which occur at Rothamsted, but not on the water-meadows, a mark (†) being placed against those species which nevertheless are common in the immediate vicinity of the water-meadows.

GRAMINEÆ (3).

†Avena pubescens, *L.*
†Dactylis glomerata, *L.*
†Festuca ovina, *L.*

LEGUMINOSÆ (4).

†Trifolium minus, *Sm.*
†—— procumbens, *L.*
†Ononis arvensis, *L.*
Vicia Sepium, *L.*

MISCELLANEOUS SPECIES (35).

Ranunculaceæ.

†Ranunculus repens, *L.*
—— auricomus, *L.*
†Ranunculus Ficaria, *L.*

Caryophyllaceæ.

†Stellaria graminea, *L.*
†Stellaria Holostea, *L.*

Hypericineæ.

†Hypericum perforatum, *L.*

Rosaceæ.

Potentilla Fragariastrum, *Ehrh.*
Alchemilla vulgaris, *L.*
†Agrimonia Eupatoria, *L.*
†Poterium Sanguisorba, *L.*

Umbelliferæ.

Conopodium denudatum, *Koch.*
Pimpinella Saxifraga, *L.*
†Anthriscus sylvestris, *Hoffm.*
†Daucus Carota, *L.*

Rubiaceæ.

†Galium verum, *L.*
Galium Aparine, *L.*

Dipsaceæ.

†Scabiosa arvensis, *L.*

Compositæ.

†Centaurea nigra, *L.*
†Carduus arvensis, *Robs.*
Senecio erucifolius, *L.*
Hypochæris radicata, *L.*
†Tragopogon pratensis, *L.*
Sonchus oleraceus, *L.*
†Hieracium Pilosella, *L.*

Primulaceæ.

Primula veris, *L.*

Scrophularineæ.

†Veronica serpyllifolia, *L.*

†Veronica officinalis, *L.*

Plantagineæ.

Plantago media, *L.*

Polygonaceæ.

†Rumex obtusifolius, *L.*

Orchideæ.

†Orchis Morio, *L.*

Liliaceæ.

Scilla nutans, *Sm.*
Fritillaria Meleagris, *L.*
Ornithogalum umbellatum, *L.*

Juncaceæ.

†Luzula campestris, *Willd.*

Cyperaceæ.

†Carex præcox, *Jacq.*

It will be useful now to enumerate by themselves those species which are found upon the water-meadows in Hampshire, but not upon the non-irrigated meadows in Hertfordshire, as this enumeration will serve to bring into prominence some, at least, of the peculiarities of the flora of water-meadows. The following are the species referred to:—

Gramineæ (10).

Phalaris arundinacea, *L.*
Alopecurus geniculatus, *L.*
Agrostis alba, *L.*
Phragmites communis *Trin.*
Glyceria aquatica, *Sm.*
Glyceria fluitans, *R. Br.*
Festuca duriuscula, *L.*
—— elatior, *L.*
—— loliacea, *Huds.*
Bromus racemosus, *L.*

Leguminosæ (1).

Medicago lupulina, *L.*

Miscellaneous Species (32).

Thalictrum flavum, *L.*
Caltha palustris, *L.*
Lychnis Flos-cuculi, *L.*
Linum catharticum, *L.*
Geum rivale, *L.*
Potentilla Anserina, *L.*
Lythrum Salicaria, *L.*
Epilobium hirsutum, *L.*
—— parviflorum, *Schreb.*
—— tetragonum, *L.*
Galium palustre, *L.*
Valeriana dioica, *L.*
—— officinalis, *L.*
Eupatorium cannabinum, *L.*
Senecio aquaticus, *Huds.*
Carduus palustris, *L.*
Lysimachia Nummularia, *L.*
Symphytum officinale, *L.*
Myosotis palustris, *Relh.*
Scrophularia aquatica, *L.*
Veronica scutellata, *L.*
—— Anagallis, *L.*
—— Beccabunga, *L.*
Scutellaria galericulata, *L.*
Plantago major, *L.*
Polygonum Persicaria, *L.*
Rumex aquaticus, *L.*
Urtica dioica, *L.*
Juncus glaucus, *Ehrh.*
—— acutiflorus, *Ehrh.*
Eleocharis palustris, *R. Br.*
Carex paludosa, *Good.*

A numerical summary of the species which have been enumerated gives the following results:—

	Gramineæ.	Leguminosæ.	Miscellaneæ.	Total.
Total on water-meadows	26	7	52	85
Total on dry meadows	20	10	55	85
Exclusively on water-meadows	10	1	32	43
Exclusively on dry meadows...	3	4	35	42
Common to both localities ...	15	6	20	41
Total in both localities	29	11	87	127

The identity of the totals in the first pair of lines, though interesting, is of course merely a coincidence. The table shows that, in all, 127 species of flowering plants occur in the two localities, that two-thirds of these occur on the water-meadows and two-thirds on the dry meadows, whilst one third of the total number are found in both localities. Half the number of species on the water-meadows do not occur on the dry meadows, and half of those on the dry meadows are not found on the water-meadows. It should be stated that the water-meadow species are restricted to those which constitute the herbage. The plants growing exclusively in the water "carriers" themselves, such as *Ranunculus aquatilis*, L., *Nuphar lutea*, Sm., *Menyanthes trifoliata*, L., *Iris Pseudacorus*, L., *Alisma Plantago*, L., *Sagittaria sagittifolia*, L., *Butomus umbellatus*, L., *Potamogeton*, sp., and *Sparganium*, sp., are beyond the scope of this inquiry, as are the species of *Rubus*, *Rosa*, *Salix*, &c., in the hedgerows.

NOTES ON THE GRAMINEÆ.

The Gramineæ of the water-meadows offer many points of special interest, whether compared with those of the dry meadow land at Rothamsted or with the dry meadows of their immediate neighbourhood. It has been stated that three grasses, common at Rothamsted, do not occur upon the water-meadows, whilst ten of the water-meadow grasses are not represented in Rothamsted Park. Nevertheless, the former three species—*Avena pubescens*, *Dactylis glomerata*, and *Festuca ovina*—are commonly found on the dry grass-lands bordering the water-meadows, whilst the following grasses not found on the water-meadows are abundantly seen in their immediate vicinity:—

Triodia decumbens, *Beauv.*
Kœleria cristata, *Pers.*
Catabrosa aquatica, *Beauv.*
Festuca gigantea, *Vill.*
Bromus asper, *Murr.*
—— sterilis, *L.*
Brachypodium sylvaticum, *Beauv.*

Of these, *Triodia*, *Kœleria*, and *Festuca gigantea*, as well as *F. ovina*, grow close down to the border of the water-meadows and then disappear. *Avena pubescens* thrives luxuriantly on non-irrigated grass-land closely adjacent. But, of the species now under consideration, those of *Dactylis* and *Catabrosa* are, perhaps, the most remarkable in their behaviour. Very abundant in the adjoining dry meadows, and, under the name of Orchard Grass, well known in America on account of its partiality for moist cool situations, I have never yet found *Dactylis* on the water-meadows. *Catabrosa*, again, is the commonest grass in the wayside ditches of the district, its herbage and panicles being conspicuously noticeable during the summer months, yet it never appears in the water-courses upon the meadows. The cause of this is difficult to determine, but it is possible that *Dactylis* and *Catabrosa* may be adversely influenced by the alternate flooding and drying of the meadows.

Only two of the water-meadow grasses, *Bromus mollis* and *B. racemosus*, are of annual duration. These, therefore, are able to maintain their position, and that indeed rather a prominent position, amongst the herbage of the water-meadows, only through shedding their seed before the hay-crop is removed. The meadows are mown at the end of June or beginning of July, by which time these species of *Bromus* are ripe, and the effect of making the hay is to detach the "seeds"—or rather the dried florets containing the grain—and to leave them upon the meadows. In panicles of *Bromus*, taken from the hay as it is being carted from the meadows to the stack, each spikelet is found to be represented merely by the two empty glumes at its base.

The most abundant of the water-meadow grasses is *Holcus lanatus*, which occupies on these moist lands a much more prominent position than it takes amongst the herbage in Rothamsted Park. The free development and multiplication of its roots combine with its tufted habit to secure it in a position it has once attained, whilst, independently of these properties, its early period of ripening seed would enable this species to keep its place. Ripe seed invariably appears before the end of June, though it is a little later than *Bromus* in this respect. *Anthoxanthum* is, however, the first of the water-meadow grasses to ripen its seeds; moreover it may, from the end of May to the beginning of July, be found in all stages of growth, from the first appearance of its panicle to the shedding of its "seed." Although a conspicuous feature in the herbage, it is not abundant.

Whilst *Bromus*, *Holcus*, and *Anthoxanthum* will have scattered their seed upon the meadows in every season before the hay-crop is removed, there are certain other grasses which may have gone to seed in hot dry summers, such as that of 1887, but which will rarely have done so in ordinary seasons. Such are *Cynosurus cristatus*, *Alopecurus pratensis*, *Poa pratensis*, *Poa trivialis*, *Glyceria fluitans*, and possibly *Avena flavescens*. But *Alopecurus* does not appear to shed its "seed"—the entire spikelet—upon the meadows. Each of the other species, however, may derive occasional support from this source, and would thus not be entirely dependent upon a perennial root-stock.

Certain other species, sufficiently abundant and generally distributed to require notice in this respect, are so late in flowering, that their seed is never ripe at the time the hay-crop is carried off. These are *Phleum pratense*, *Agrostis alba*, *Lolium perenne*, and the Festucas. They therefore retain their position solely through the perennial nature of their root-stocks. *Phleum pratense* has a preference for moist habitats; and, excepting *Phragmites communis*, it is the latest of the water-meadow grasses to come into flower; its herbage is young and fresh, and the inflorescence is usually only just emerging from its sheath, at the time the meadows are mown. *Lolium perenne* is abundantly represented, and, for quantity, probably occupies the second or third place after *Holcus lanatus*. Of the Festucas, it is the broad-leaved forms that flourish, whilst the narrow-leaved forms, of which *Festuca ovina* is the type, are scarcely represented. The case is almost reversed in Rothamsted Park, where *Festuca ovina* is one of the most prevalent grasses, whilst *F. pratensis* is rapidly diminishing. Inasmuch as the broad-leaved fescues, of which *F. pratensis* may be taken as the type, offer to the air a greater leaf-surface for transpiration, their demand upon the moisture of the soil would be greater than in the case of the fine-leaved forms; hence the former might languish and die out in dry situations where, on the other hand, *F. ovina* and its nearest allies would thrive.

The distribution of the gramineous species upon the water-meadows presents some points of interest. The species of *Bromus*, *Holcus*, *Anthoxanthum*, *Cynosurus*, *Alopecurus*, *Poa*, *Avena*, as well as *Glyceria fluitans*, are generally distributed. Other species are distinctly local, even in the limited area under notice. Thus, *Phalaris arundinacea*, *Aira cæspitosa*, *Phragmites communis*, and *Glyceria aquatica* are practically restricted to the borders of the water-courses, and are seldom, or never, to be seen in the open meadow. *Phragmites*, indeed, does not stray from the river-side, though its monopoly there is to some extent disputed by *Phalaris* and by *Festuca elatior*. *Phalaris arundinacea*, *Aira cæspitosa*, and *Glyceria aquatica* are able, on account of their vigorous habit and robust growth, to smother the finer grasses, and, attracted by the greater moisture, they frequently occupy all the space immediately adjoining the water-courses.

Three species of the water-meadow grasses exhibit interesting modifications, sufficiently marked in some cases to constitute subspecific characters. These are *Lolium perenne*, *Festuca pratensis*, and *Glyceria fluitans*. In the forms of *Lolium perenne* the rhachis may be found long or short, and occasionally branched; the spikelets large or small, crowded together or remote, rounded or flattish, with not infrequently a small inner empty glume at the base of each; the flowering glumes, usually awnless, are sometimes awned. Of the fescues it is not difficult, taking *Festuca pratensis* as the type, to select specimens showing a gentle series of gradations, on the one hand, into *F. elatior*, and, on the other hand, into *F. loliacea*. Moreover, specimens of the last-named may be found in which the spikelets are all sessile and the upper empty glume almost obsolete; such forms of *F. loliacea* approach closely to *Lolium perenne*.

NOTES ON THE LEGUMINOSÆ.

The leguminous herbage of the water-meadows is scanty. The only water-meadow species not represented in the dry meadow at Rothamsted is *Medicago lupulina*; and this is common in the dry meadows adjoining the water-meadows. *Trifolium minus* and *T. procumbens*, though not found on the water-meadows, are common both on the adjoining dry grass-lands and at Rothamsted.

NOTES ON THE MISCELLANEOUS SPECIES.

Of the miscellaneous flowering-plants found upon the water-meadows, the following appear to be the most common and the most generally distributed amongst the herbage :—*Caltha palus-*

tris, *Cardamine pratensis*, *Cerastium triviale*, *Lychnis Flos-cuculi*, *Geum rivale*, *Galium palustre*, *Senecio aquaticus*, *Rumex Acetosa*, *Juncus acutiflorus*, and *Eleocharis palustris*; whilst *Lysimachia Nummularia* is a conspicuous feature of the aftermath herbage. Less prominent, but very noticeable, are *Valeriana officinalis*, *Chrysanthemum Leucanthemum*, *Carduus palustris*, *Achillea Millefolium*, *Myosotis palustris*, *Plantago lanceolata*, *Ajuga reptans*, *Prunella vulgaris*, and *Rumex crispus*. Of the 20 species here enumerated, there are, however, only half a dozen which also occur on the dry meadows at Rothamsted, namely, the species mentioned of *Cerastium*, *Achillea*, *Plantago*, *Ajuga*, *Prunella*, and *Rumex Acetosa*.

The special characters of the water-meadow flora may be still further illustrated by an enumeration of those miscellaneous species which occur on the dry meadows at Rothamsted and also on land adjoining the water-meadows, but not on these latter themselves. These, obviously, are species which are kept off the water-meadows as an effect of the periodical flooding of the latter, as there can be no adverse influence of soil or situation. They comprise:—

Ranunculus repens, *L.*
—— Ficaria, *L.*
Stellaria Holostea, *L.*
Agrimonia Eupatoria, *L.*
Anthriscus sylvestris, *Hoffm.*
Daucus Carota, *L.*
Galium verum, *L.*
Galium Aparine, *L.*
Scabiosa arvensis, *L.*
Centaurea nigra, *L.*
Carduus arvensis, *Robs.*
Tragopogon pratensis, *L.*
Hieracium Pilosella, *L.*
Luzula campestris, *DC.*

It deserves to be noted that of the 112 counties and vice-counties into which Britain has been divided by Watson, two of the water-meadow species—*Epilobium tetragonum* (33 counties) and *Rumex aquaticus* (37)—occur in less than one third of them; whilst five other species—*Thalictrum flavum* (65), *Lysimachia Nummularia* (67), *Valeriana dioica* (69), *Scrophularia aquatica* (70), and *Carex paludosa* (70)—are recorded for less than two thirds.

All the species enumerated as occurring upon the water-meadows have therefore been identified upon grass-lands which, as stated at the outset, are subjected to the intermittent influence of running-water. No notice has been taken of adjoining marsh-lands, which are under the influence of stagnant water; on these, indeed, some of the species already noted are absent, whilst others, such as species of *Pedicularis*, *Anagallis*, *Mentha*, *Orchis*, &c. are present.

Concerning the cryptogamic plants, it need only be said that, excepting a few species of Mosses in each case, *Ophioglossum vulgatum*, L., occurs sparsely on the dry meadows at Rothamsted, and *Equisetum palustre*, L., on the water-meadows.

Whatever peculiarities exist in the herbage of the water-meadows which I have had under observation are probably largely attributable to the periodical influence of running-water. The flooding of the meadows at intervals during the winter enables the herbage to enjoy a higher temperature than is the case upon non-irrigated grass-lands, and this promotes early spring growth. The meadows are, moreover, rendered independent of the effects of deficient rainfall, so that even in seasons of the severest drought the removal of the hay-crop brings to view a sward which is bright, fresh, and verdant. Thus, whether the season be wet, or dry, or of average rainfall, it is much the same to the water-meadows. Any seasonal influences to which they may be susceptible must therefore be sought rather in the general conditions of atmospheric temperature, and in the duration of sunshine in the growing season, than in the amount and distribution of the rainfall.

Of the origin and history of these water-meadows little or nothing is known. Marshall, writing in 1798, asks, "When and in what manner, was so great and spirited a public work executed?" I can find no record of their having been made the subject of any special botanical investigation, but the following quotation from the author just mentioned conveys some idea as to their condition a century ago *:—

"The herbage of the watered beds is various in species; as ray grass, the meadow poe, the marsh and other bent grasses, and the meadow fescues; the *loliacea* and the *pratensis*, here putting on very different appearances. On the sides of the trenches, and ditches, the flote fescue, reed canary grass (*Phalaris arundinacea*), and the water poe (*Poa aquatica*) are common; also the meadow rue (*Thalictrum flavum*), and the water dock. One meadow I observed was almost shaded over with the common dock; which appears to be a prevailing weed of the well-formed grounds; and almost the only one."

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* The Rural Economy of the Southern Counties; comprizing Kent, Surrey, Sussex, the Isle of Wight; the Chalk Hills of Wiltshire, Hampshire, &c. By Mr. Marshall. 1798, vol. ii. p. 335.

On a New Species of *Cytinus* from Madagascar, constituting a New Section of that Genus. By EDMUND G. BAKER, F.L.S.

[Read 1st March, 1888.]

(PLATE XIX.)

IN the last parcel of plants sent by the Rev. R. Baron, F.L.S., from Madagascar was a curious parasite of which the following communication is a description. It was found by him in the forest about thirty miles east of Mandritsara, North-west Madagascar. Contrary to the other species of the genus *Cytinus*, this plant grows on the trunk of a small tree. Specimens of the host were also forwarded with the parasite; the flower material is incomplete, but it apparently belongs to *Dicoryphe*, a curious genus of *Hamamelideæ* endemic in Madagascar. I will give in the first place comparative characters of this new subgenus, and of the three already known.

Subgenus I. EUCYTINUS.

Ad Cistarum radices parasitica. Caulis productus. Monoicus. Flores dense spicati. Perianthii segmenta 4. Bracteolæ 2. Connectivum supra loculos haud productum. Stigma capitatum 8–10-sulcatum. Placentæ 8–10, simplices. Species 1.—*Regio Mediterranea.*

Subgenus II. HYPOLEPIS (*Pers.*).

Ad Eriocephali et Agathosmæ radices parasitica. Caulis productus. Dioicus. Flores 1–3 spicati. Perianthii segmenta 6. Bracteolæ 2. Connectivum supra loculos productum. Stigma globosum, lamellis 12–14 cuneato-subulatis. Placentæ 12–14, ramosæ. Species 1.—*Africa australis.*

Subgenus III. BDALLOPHYTON (*Eichl.*).

Ad radices parasitica. Caulis productus. Dioicus. Flores numerosi dense spicati. Perianthii segmenta 4–9. Bracteolæ 0. Connectivum supra loculos longe productum in *Cytino americano*, R. Br., haud productum in *C. Andrieuxii*, Hemsl. Stigma radiatum obscure lobatum. Placentæ 10–14. Species 2.—*Mexicanæ.*

Subgenus IV. Botryocytinus (*Baker fil.*).

Ad arborum ramos parasitica. Caulis haud productus. Dioicus. Flores 3–4 glomerati, involucro circumcincti. Perianthii segmenta 6. Bracteolæ productæ. Connectivum supra loculos haud productum. Stigma radiato-oblatum. Placentæ 9–12, simplices. Species 1.—*Madagascar.*

Description of Parasite.

1. *Mode of Growth.*—The parasite grows on the trunk of the host in a manner somewhat similar to *Apodanthes* (see Trans. Linn. Soc. xxvii. p. 67, t. 22), but with this important difference: in *Apodanthes* the flowers are solitary, whilst in the present plant they grow in clusters of three or four, and each cluster is surrounded by numerous orbicular scale-leaves, similar in texture and appearance to those of the perianth. The inner leaves of this involucre are large, orbicular, and imbricated, and the outer ones, as in the involucre of many of the Compositæ, are gradually smaller and smaller, still retaining their orbicular shape, the outermost close to its attachment being reduced to a minimum. As to the mode of attachment, the parasite is on its lower surface wedged with irregular protrusions into the cortex of the host, the boundary between the parenchyma of the host and parasite being clearly marked. From the appearance of that portion of the host in contact with the parasite, it is evident that this latter has been gradually emerging, and that its vegetative portion has been formed in the interior of the host.

2. *Bracts and Perianth.*—From the staminate plant alone it would be difficult to draw any line of distinction between the bracts and flower-wrapper, but by studying the pistillate plant this difficulty disappears. At the base of the ovary there are several whorls of orbicular bract-leaves, and from a little under the apex of the ovary arise six much imbricated ovate perianth-segments. I gather from Mr. Baron that the perianth, bracts, and leaves of the involucre are all white in the fresh state; when dry they are the same dead brown which is familiar to us in most other parasites. In the staminate plant the whorls of leaves are much closer together; however, drawing an analogy from the female plant, we may consider the outermost as bracts and the two inner whorls as perianth. In the staminate plant the tube of the perianth is hollow, and is united to the staminal column by six septa, which divide it into six partitions. On the lower

portion of the perianth-segments, on the lower portion of the style, and on the perianth-tube are numerous multicellular cylindrical or club-shaped processes.

A transverse section of a perianth-segment shows it to be composed of homogeneous parenchymatous tissue, the cells being roundish or pentagonal; the upper and lower epidermis are similar in structure, and stomata do not appear to be present. At the base of the perianth-limb at the point of juncture with the perianth-tube there are usually about five fibro-vascular bundles in each of the perianth-segments; these, however, radiate like a fan from the base upwards, and branch dichotomously, and just beneath the apex of the perianth-segments the termination of some twenty bundles may be counted. A case of apparently abnormal growth of the perianth was met with in one of the female flowers examined, one of the perianth-segments becoming trifid a short distance above the base.

3. *Andrœcium.*—The parasite is unisexual, the separate clusters consisting only of one sex. The staminate flower is globose and about ½ an inch in diameter. The anthers, twenty or more in number, are sessile on the column, and are arranged in a verticillate manner. The column, which is solid at the base, in the upper part is hollowed out in the middle, and has the anthers arranged on the outside contiguous to one another in a regular manner. The anthers are bilocular, and dehisce extrorsely and longitudinally, the two loculi being parallel. The pollen is somewhat peculiar, being compound; it is composed of four cells, and the compound grain has a diameter of ·03 millim. The position of the four cells varies; sometimes they are arranged in the form of a tetrahedron, or they may be in the form of a pyramid.

If a transverse section be made of the ring of stamens, the column will be seen to be composed of homogeneous parenchyma, with a simple series of 8–10 vascular fascicles. In the wall of the anther the external layer of cells is thickened, and fibrous cells are absent. The composition of the bundles is of a somewhat simple character, the xylem element being represented principally by spiral vessels, and the perixylem is composed of short thin-walled cells. The cells composing the parenchyma of the column have brownish-coloured contents, and give a decided dark blue-black coloration with solution of sulphate of iron, thus indicating the presence of tannic, and probably other astringent acids.

4. *Gynæcium.*—The female flower is larger than the male flower, but like this latter it occurs in clusters, each containing 3–4 flowers, and these clusters are sessile upon the trunk of the host. The perianth-tube is about as long as the lobes, and is entirely adnate to the ovary. The lobes of the perianth are six in number.

The ovary is unilocular, and the placentæ are 9–12 in number, and are long and sinuous. The ovary is so nearly inferior that only the summit projects from the enveloping perianth-tube. If a transverse section, taken from the very top of the ovary, be examined, it will be found to be spuriously multilocular; by spuriously I mean that there is only one central loculus containing placentæ, but that there are several other smaller loculi which are destitute of placentæ, and which are not found in a section taken lower down in the ovary (see fig. 5). The ovules, which are very numerous, are erect and orthotropous, and have only one integument; the various stages of the development of this integument can often be traced in a single section of the ovary, the ovules at the base of the placentæ being in a younger state than those at the apex. The first stage consists of a protuberance on the walls of the placenta; then other ovules can be seen, with the nucleus projecting like a cone from the encircling integument; and, finally, the integument when fully formed appears to consist of two layers of cells. The ovules of this parasite differ very considerably from those of *Rafflesia*, as described by Robert Brown[*]. In this latter plant they are curiously anatropous, with a dilatation at the apex of the funiculus.

The style is short, solid, and columnar; the stigma is capitate, and has apparently as many lobes radiating from an umbilicate centre as there are placentas in the ovary. The viscid surface extends all over the summit and a little down the sides of the stigma. There is a dilatation at the base of the style, which will be seen represented by two protuberances in the vertical section (see Plate XIX. fig. 2).

As all the specimens of the parasite were gathered at about the same date, the fruit and seeds are unknown[†]. Doubtless the fruit is baccate and the seeds minute and very numerous, as in the other species of *Cytinus*. The embryo of the Cytinaceæ is small and nondifferentiated in the form of a roundish mass of cellular tissue.

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[*] Trans. Linn. Soc. vol. xix. p. 242, t. 22–26.

[†] For a description of the seeds of Cytinaceæ, see Solms-Laubach, Trimen's Journ. Bot. 1874, pp. 308–318; or Solms-Laubach, "Ueber den Bau der Samen in den Familien der Rafflesiaceæ und Hydnoraceæ," Bot. Zeit. 1874, Nos. 22–25.

I propose to call the species CYTINUS BARONI, after its discoverer. This makes a fifth species of the genus *Cytinus*, and until the present time no member of the Suborder *Rafflesieæ* has been recorded from Madagascar. The commonest species of *Cytinus*, *C. Hypocistis*, Linn., is confined to the Mediterranean region; another species, *C. dioicus*, Juss., is found at the Cape of Good Hope; and two members of the same genus have been described from Mexico. The only member of the nat. order Cytinaceæ that has been found in Madagascar is a species of *Hydnora*, which was seen by M. Grandidier *, but of which no specimens were brought home; the structure in this genus is very dissimilar to that found in *Cytinus*.

EXPLANATION OF PLATE XIX.

Fig. 1. Two flowers of *Cytinus Baroni*, natural size.
2. Longitudinal section of female flower, × 3.
3. Longitudinal section of male flower, × 3.
4. Stigma showing radiate lobation, magnified.
5. Side view of the same, less magnified.
6. Transverse section of ovary. A, near apex; B, lower down. × 9.
7. Transverse section of ring of stamens, × 9.
8. Transverse section of anther, showing two loculi, × 75.
9. Pollen, × 450.
10. Transverse section of perianth-tube, male flower, × 9.
11. Placenta, with ovules, × 150.
12. Cylindrical process, from near base of perianth-tube, × 150.
13. Longitudinal section of male flower, in an early stage. H, the host. × 3.

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* See Bull. Soc. Linn. Paris, 1886, p. 545.

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Massee & Morris.

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Fig. 3.
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Fig. 2.
×350
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Fig. 1.
b
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b

VIII
PTYCHANTHE.
Present Limits of the Genus Gentiana.
VII.
LISSANTHE.
IV.
STEPHANANTHE.
G. purpurea.
n
G. verna.
n
Voyria.
G. Amarella.
n
Erythræa.
II
KERATANTHE.
III
LOPHANTHE.
Frasera
Swertia
Ophelia
G. Jamesonii
n
n
n
Halenia.
Chironia.
I
ACTINANTHE.
V.
ASTERANTHE.
VI.
LIMNANTHE.
HAPLANTHE.
G. aurea.
n
Villarsia.
n
G. lutea.
Eustoma.
(Hypothetical)

T.H. Huxley del.

J.N. Fitch lith.

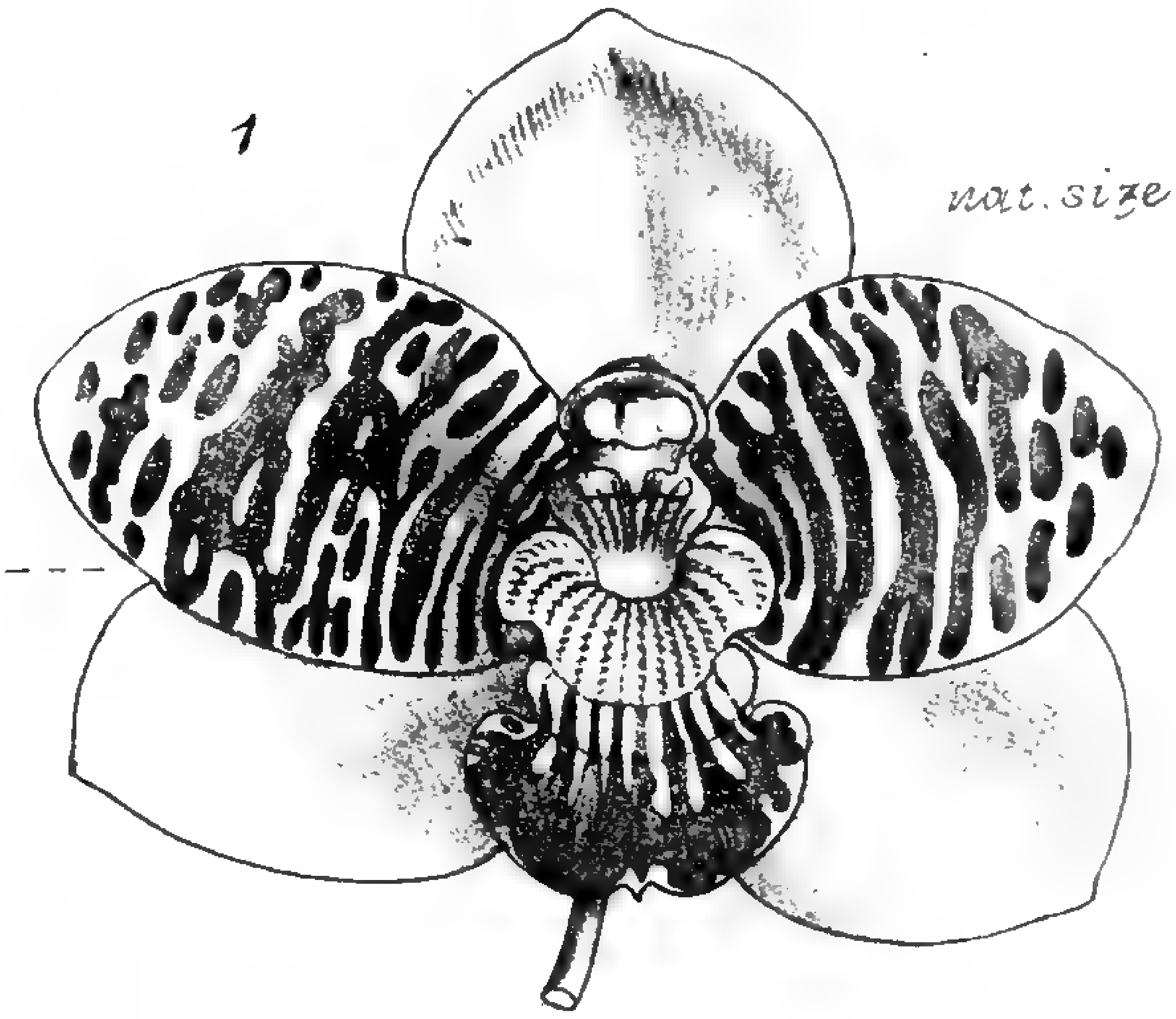
OLOGY OF FLOWER OF THE

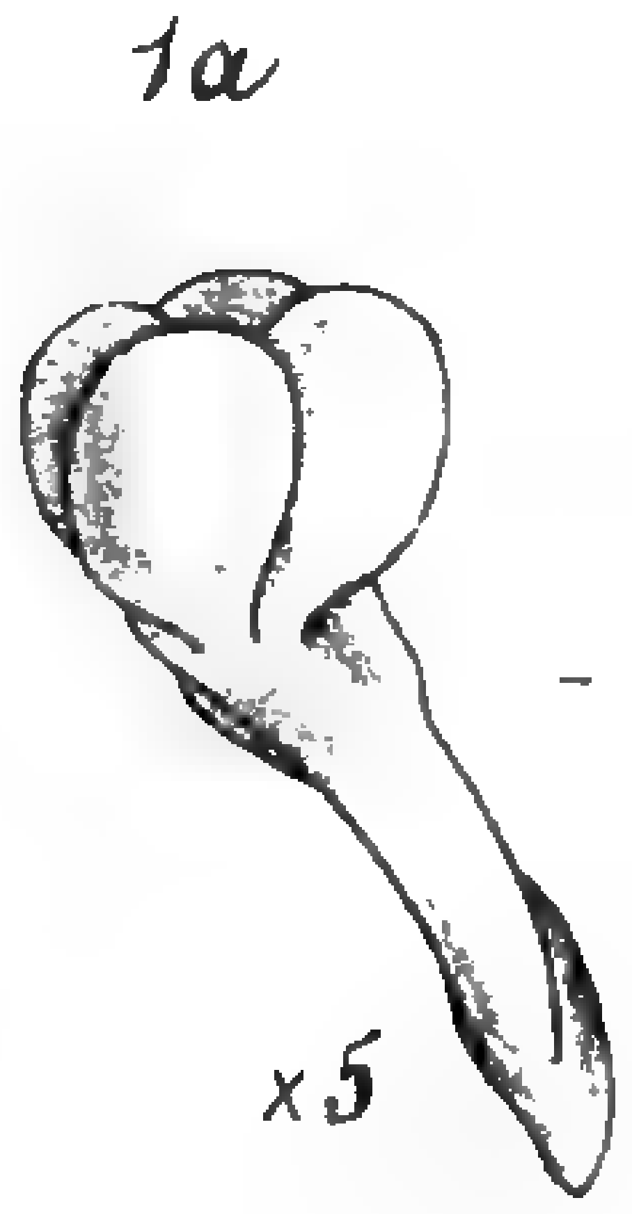
M.Smith del.

VACCINIUM INTERMEDIUM, *Ruthe*.

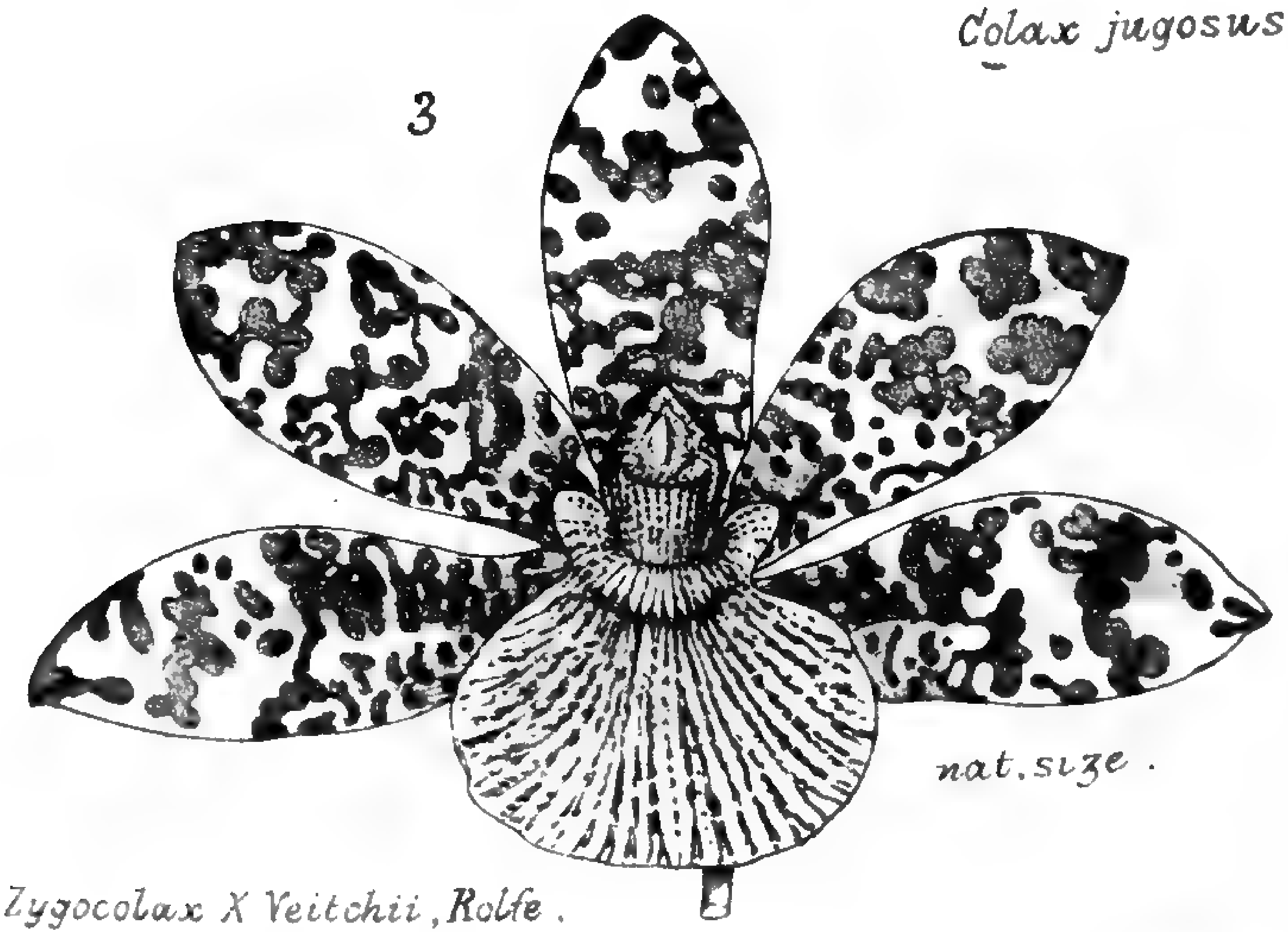
J.N.Fitch lith.

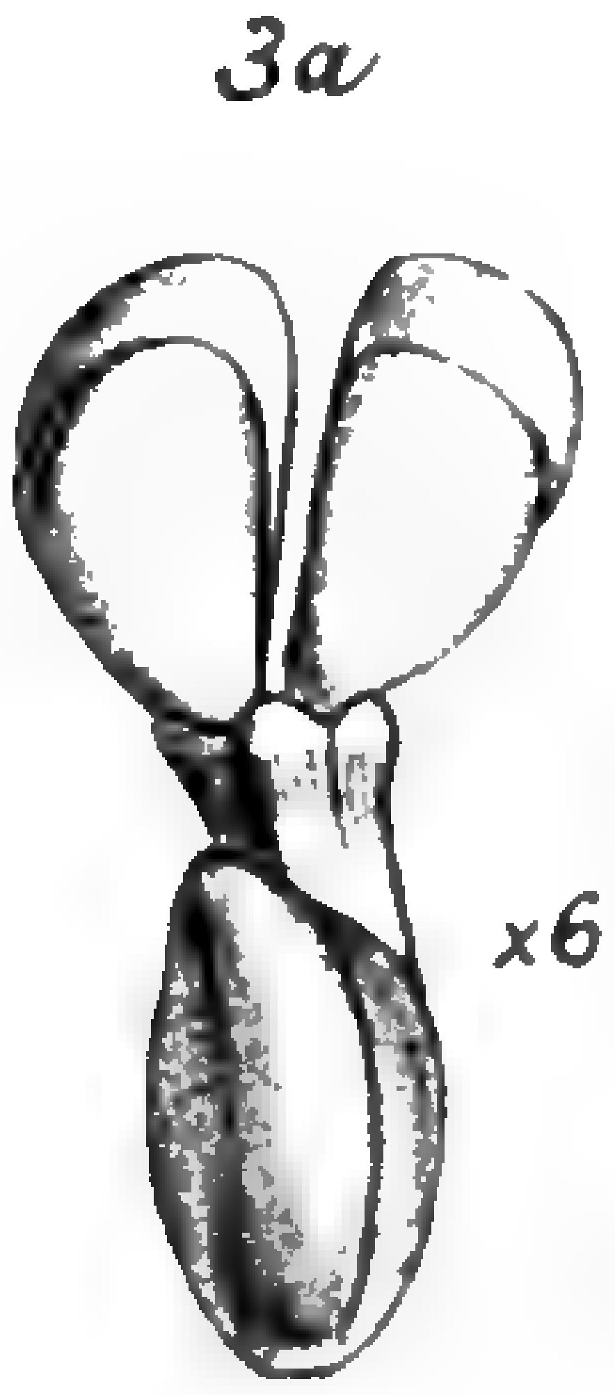
R. A. Rolfe, del.



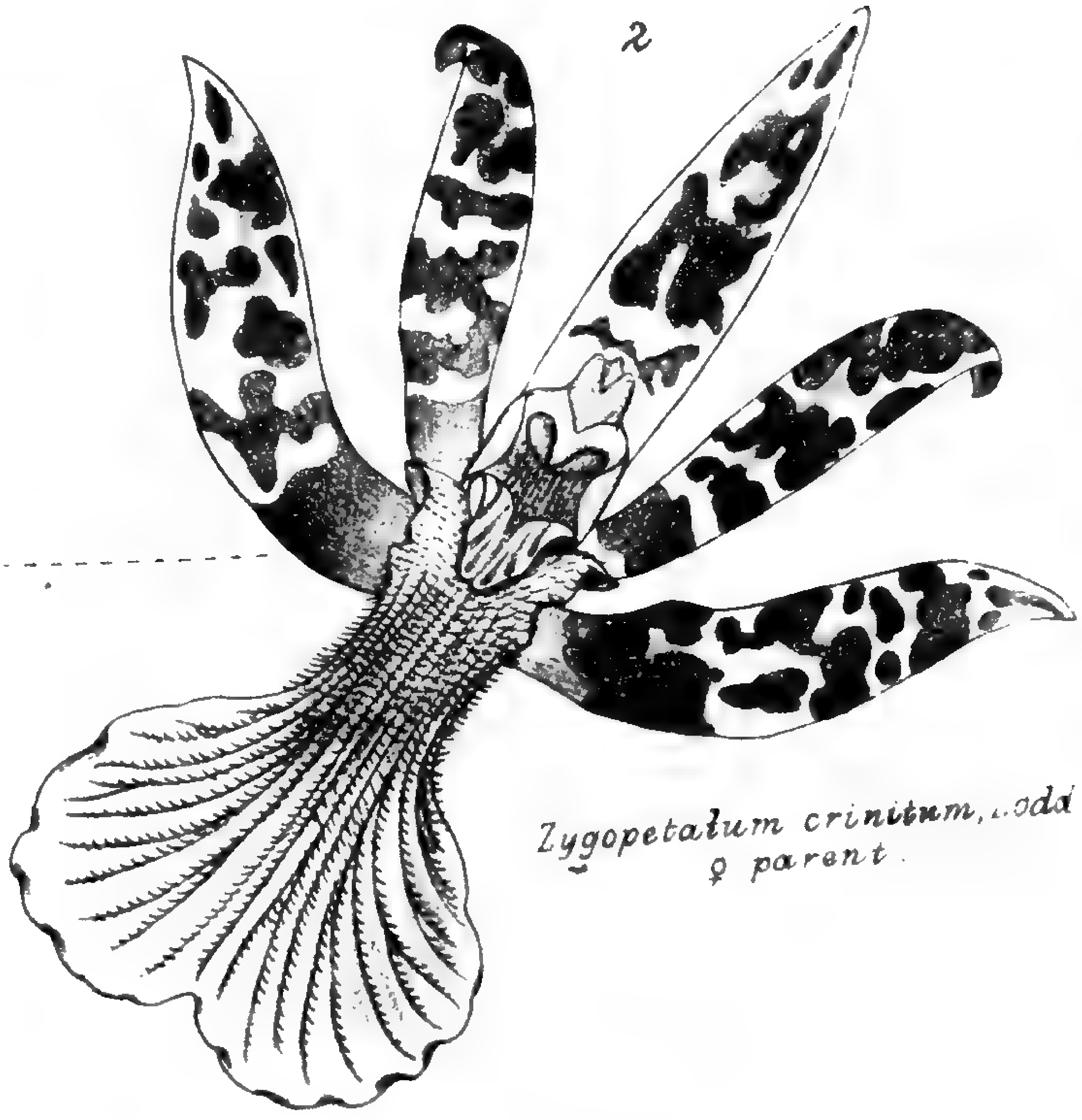


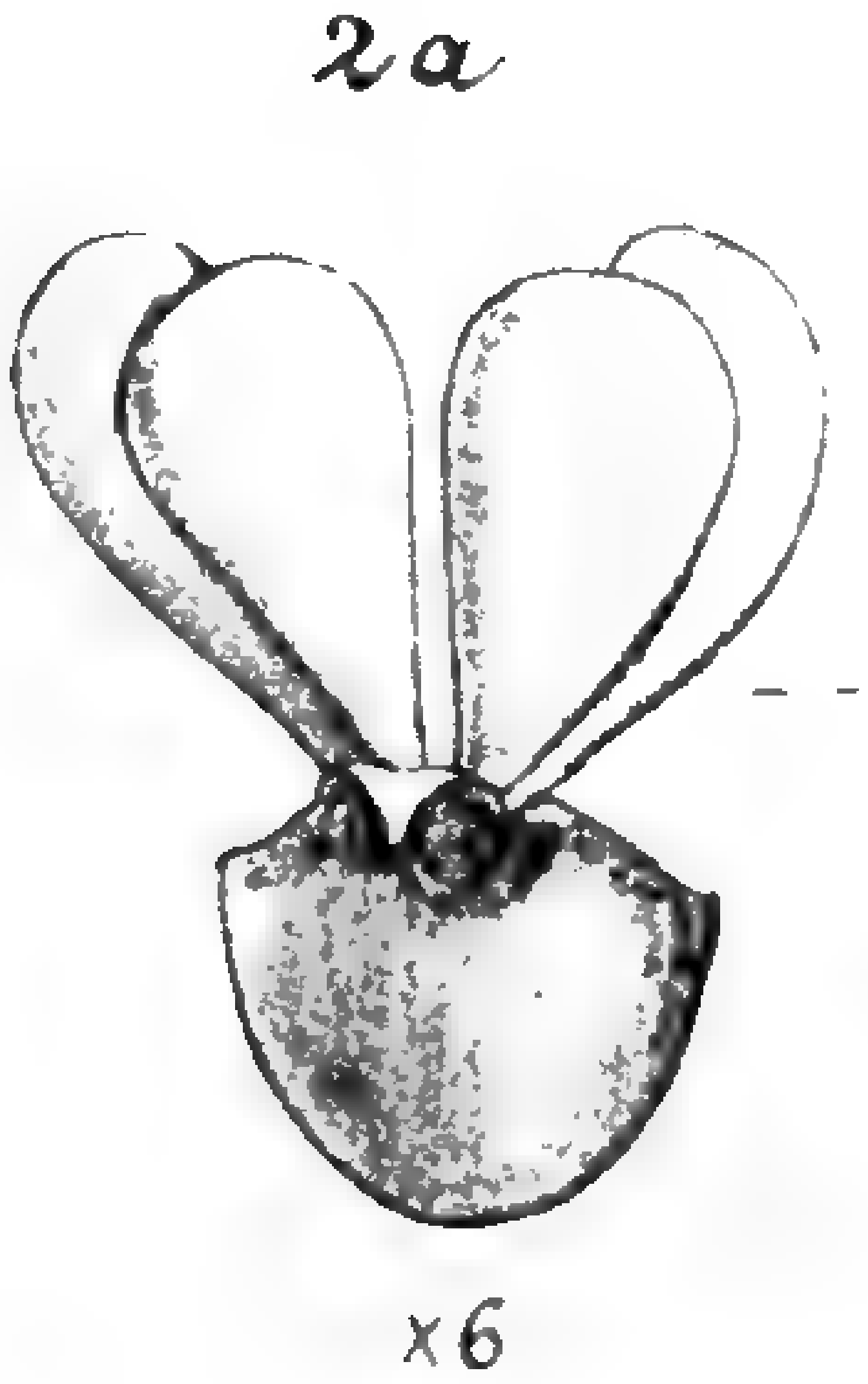
Colax jugosus, Lindl.
♂ parent.





Zygocolax × *Veitchii*, Rolfe.
Hybrid.





Zygopetalum crinitum, Lodd.
♀ parent.

J. N. Fitch lith.

BIGENERIC ORCHID HYBRIDS.

Fitch imp.

Tolypothrix
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H. K. del.
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Balanophora
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nat. size

Morgan, lith. T. Ito, del. West, Newman, imp.

1–4, SCOTT, NUCLEI IN OSCILLARIA & TOLYPOTHRIX.
5–8, TOKUTARO ITO, BALANOPHORA NEW TO JAPAN.

H.N. Ridley.

LINN. SOC. JOURN. BOT. VOL. XXIV. PL. 6.

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J.N.Fitch del.

ORESTIAS ELEGANS, *Ridley*.

Fitch imp.

S. MOORE.

LINN. SOC. JOURN. BOT. VOL. XXIV. PL. 7.

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E. Carter sc.

INFLUENCE OF LIGHT ON PROTOPLASM.

Mintern imp.

Potter.

Bujeau lith

Mintern imp.

ALGAL GROWTH ON LIVING TORTOISE.

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Vaizey del.

IN MOSSES

E. Carter sc.
Mintern imp.

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J R Vaizey del.

E Carter sc.

Mintern imp.

MORPHOLOGY SPOROPHORE IN MOSSES.

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J.R.Vaizey del.

E. Carter sc.
Mintern imp.

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Q
× 300
41.
O
ex.
end
Q
× 300
Q
O
42.
Q
c
cs
sh
O
× 300
43.
O
Q
Q
end
ex
O
46.
end
45.
O
Q
Q
O
44.
O
I
II
II
III
II
II
Q
III
III
III
II
II
III
II
II
II
II
I
O
48.
× 300
47.
ep
scl
× 520
i
ml
49.
× 300

Vaizey del.

MORPHOLOGY SPOROPHORE IN MOSSES.

E. Carter sc.
Mintern imp.

Spencer Moore.

LINN. SOC. JOURN. BOT. VOL. XXIV. PL. 13.

1.a
1.b
1.c
2.
3.d
5.
3.a
3.b
3.c
4.
6.a
6.c
6.d
7.d
6.b
7.b
7.c
7.e
7.a
8.a
n
8.c
8.d
n
8.e
n
8.g
8.b
9.
8.f
n
10.a
10.b
10.c
10.d
10.e
10.f
10.h
n
10.g
10.i
n

E. Carter sc.

Mintern imp.

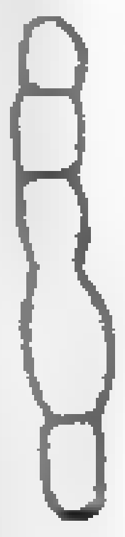
UPON PROTOPLASM.

11.a
11.b
11.e
11.f
11.g
11.h
11.c
11.d
14
15
11.i
12.a
12.c
12.e
13.a
13.c
n
17.
18.
12.b
12.d
13.b
13.d
16.a
16.c
n
16.d
22.a
22.b
16.b
22.c
19.a
19.b
n
n
20.a
20.b
20.c
21.a
21.b
22.d
n
n
20.d
20.e

Mintern imp.

E. Carter sc.

INFLUENCE OF LIGHT UPON PROTOPLASM.

23.ª


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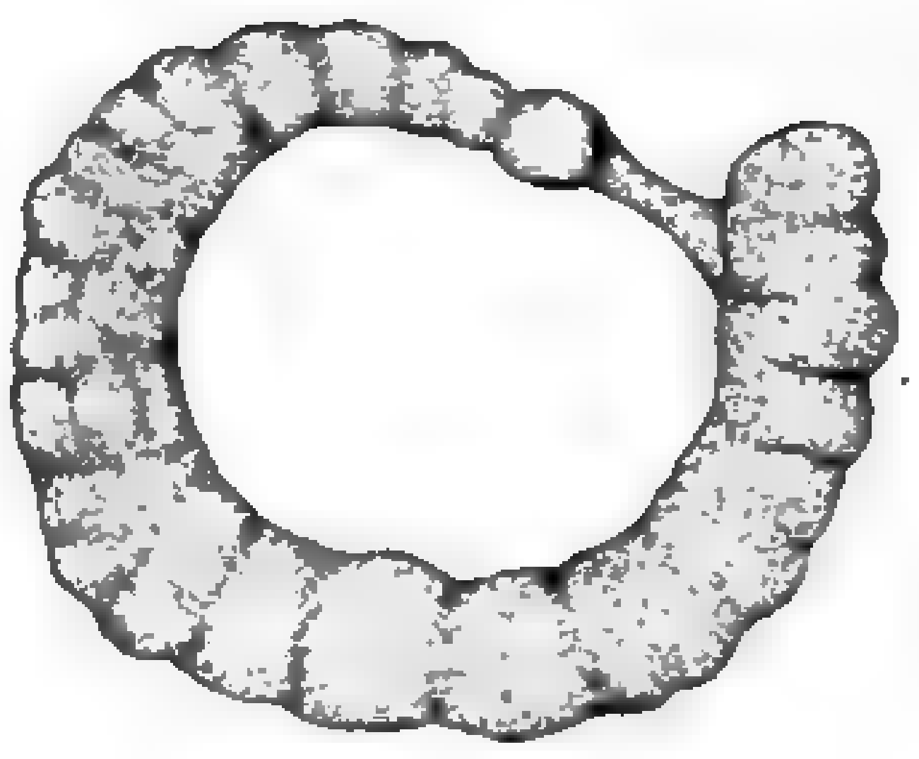

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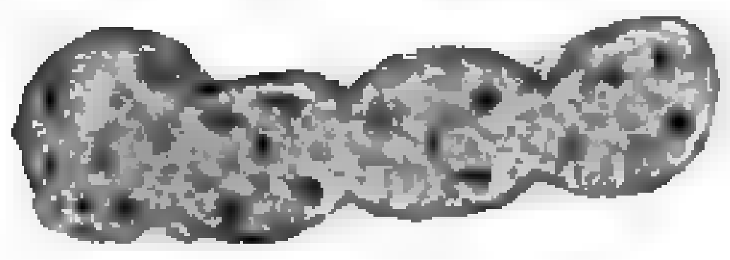

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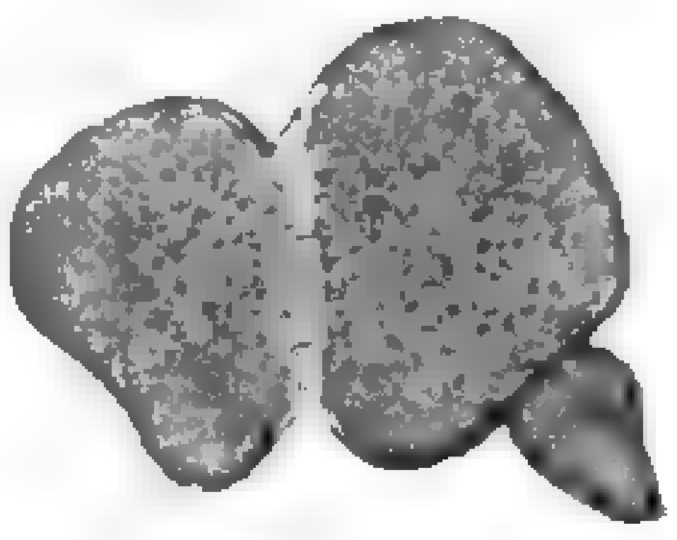

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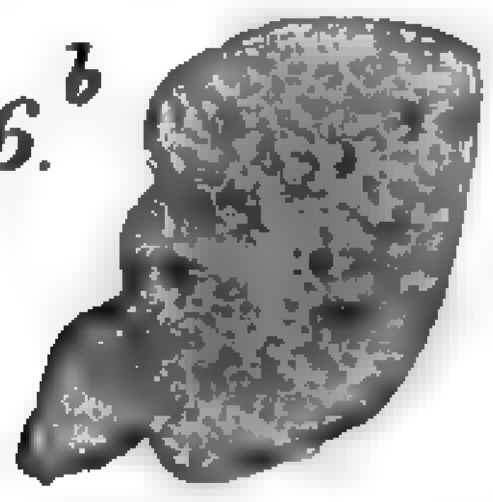

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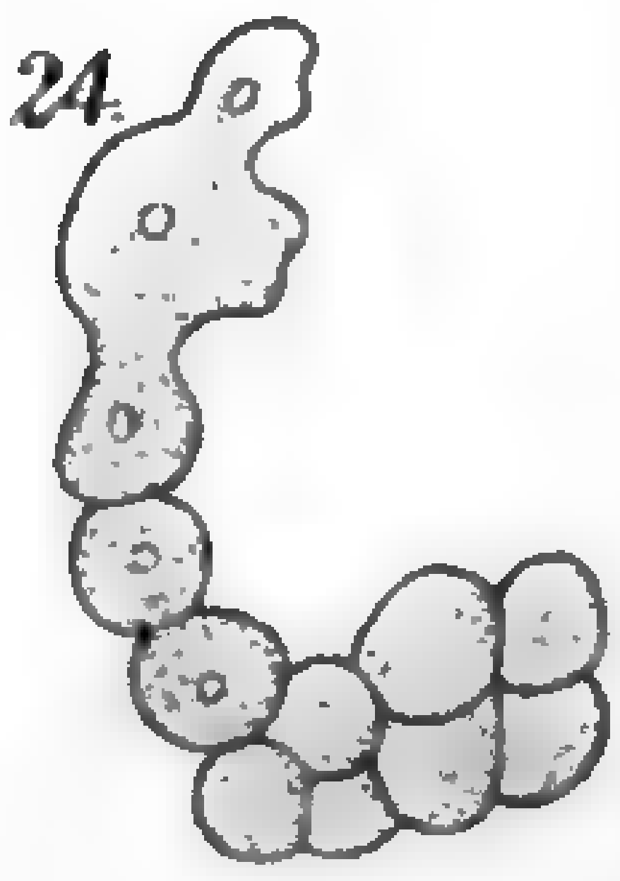

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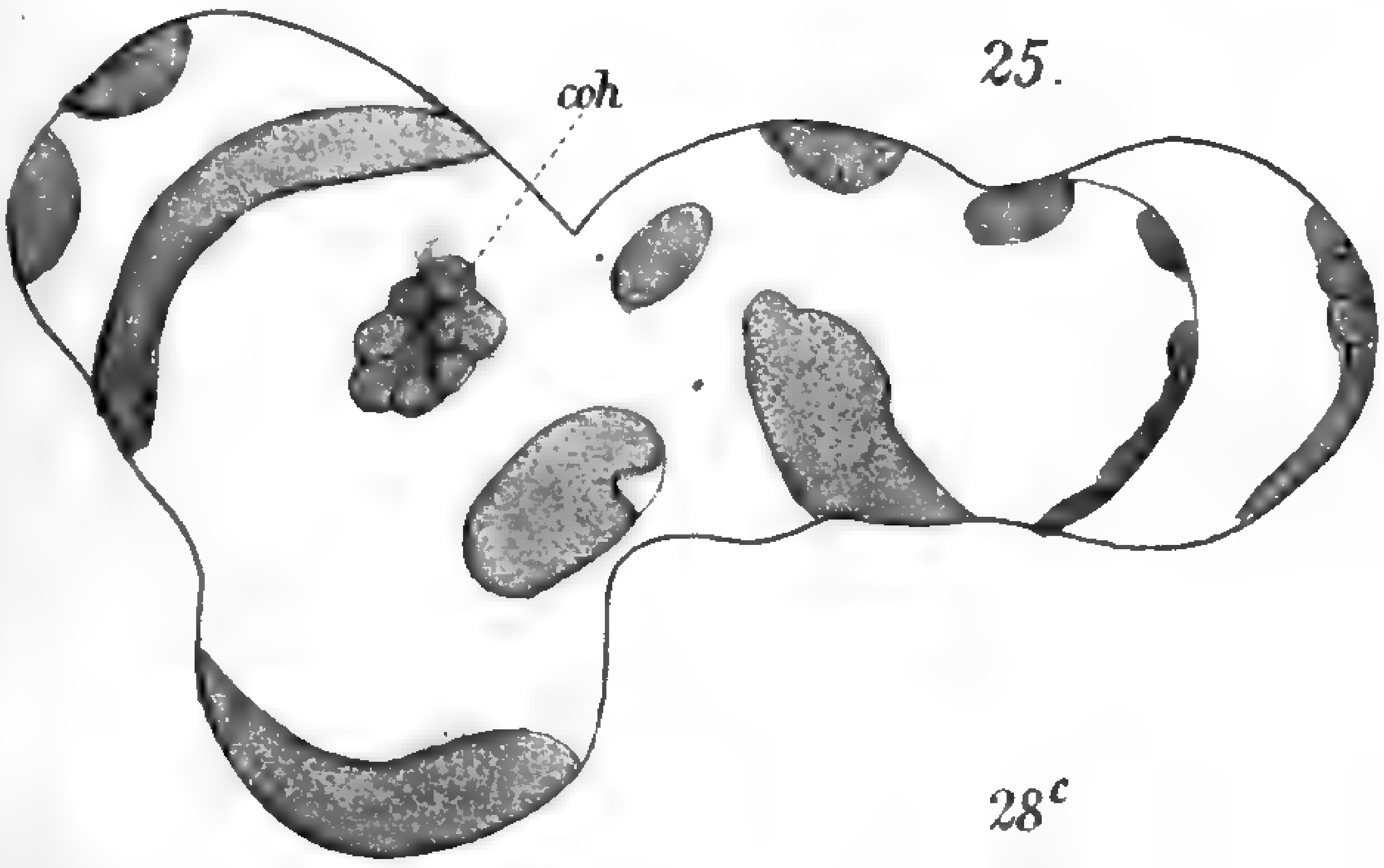

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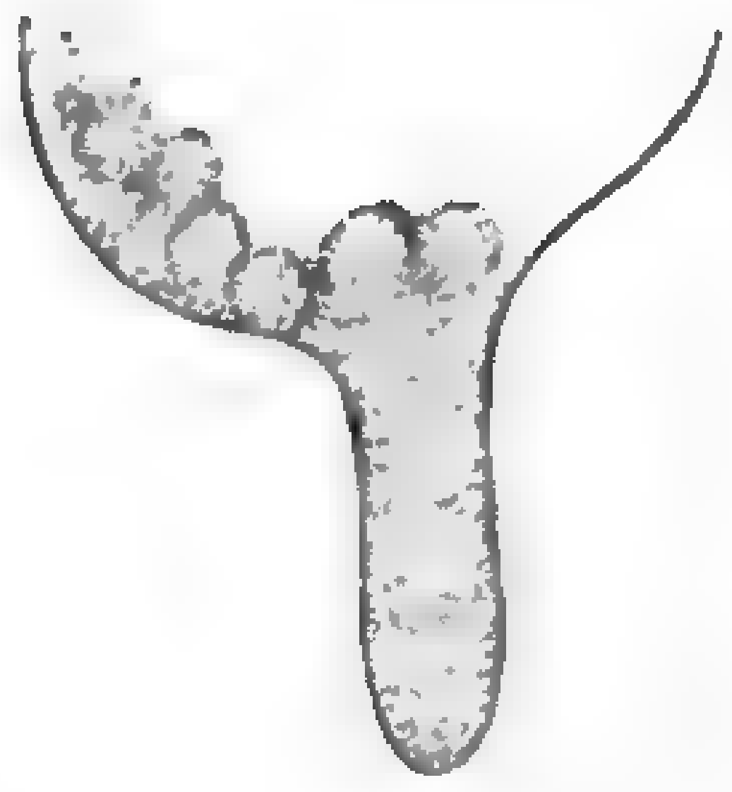

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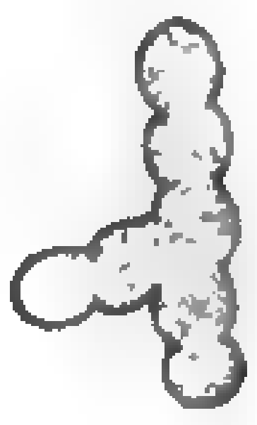

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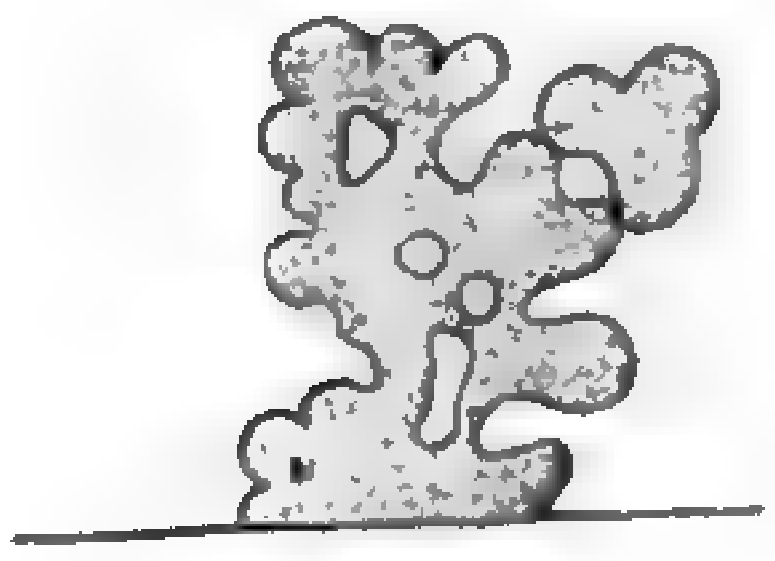

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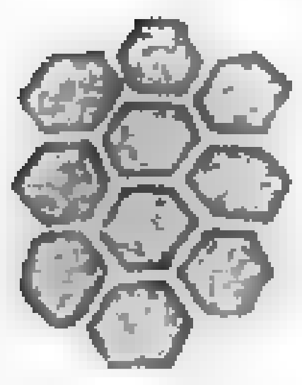

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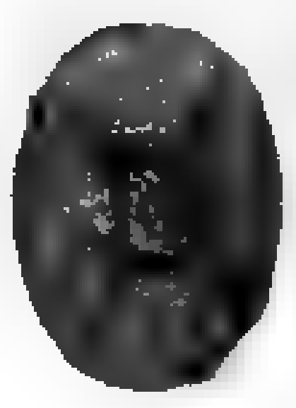

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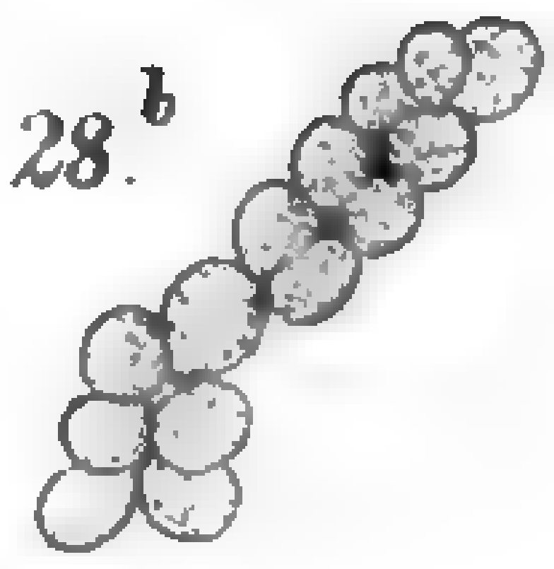

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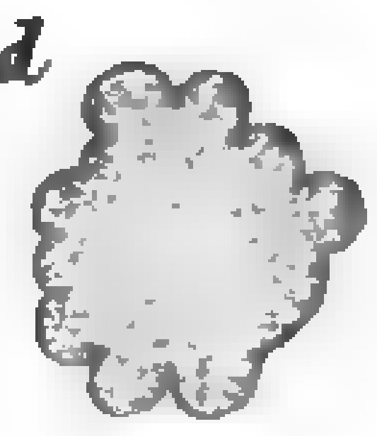

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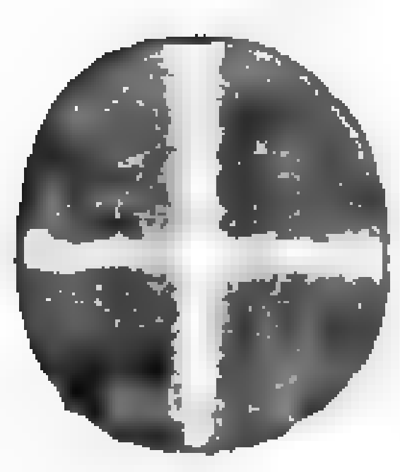

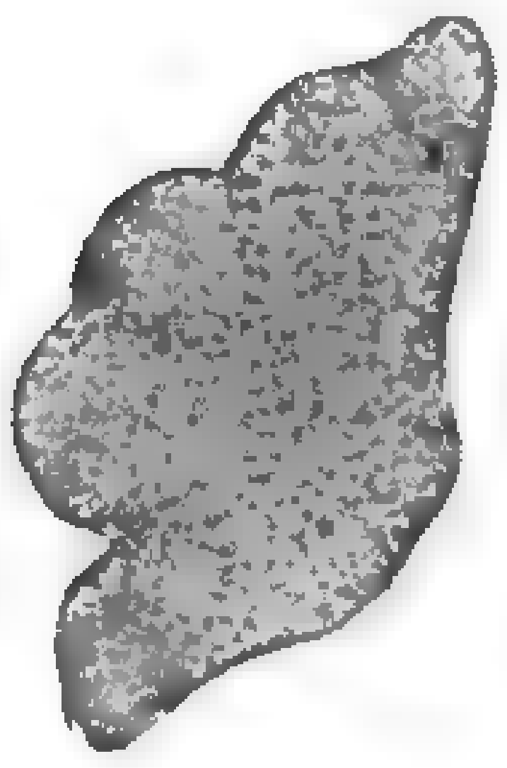

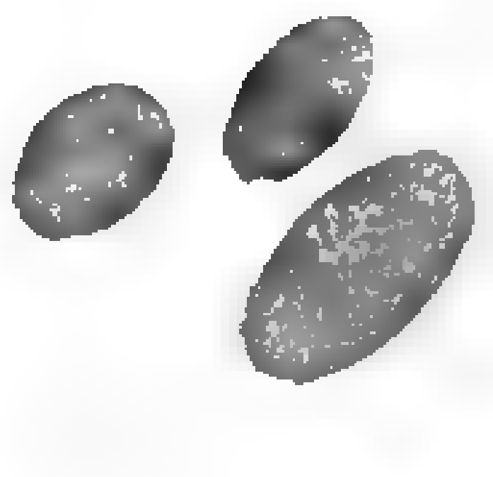

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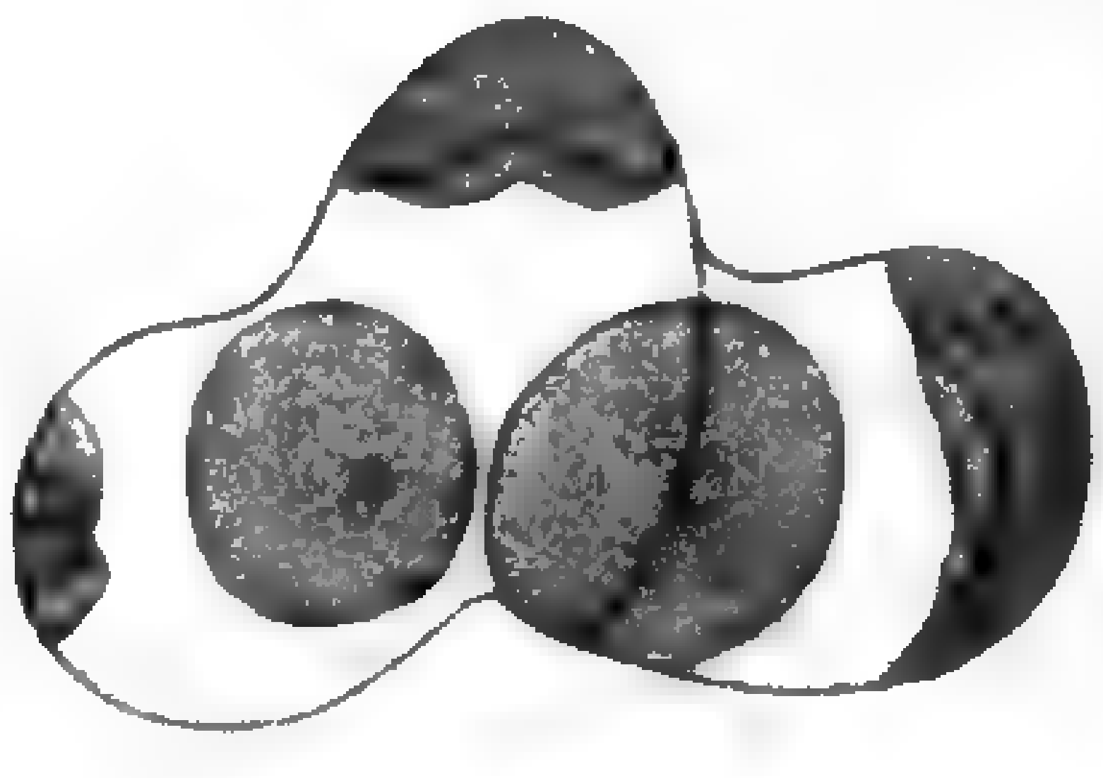

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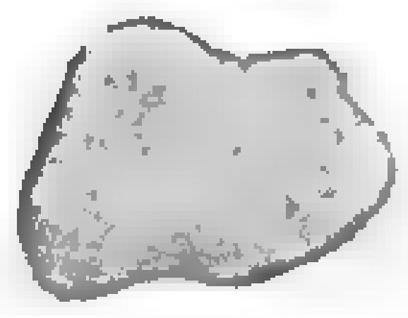

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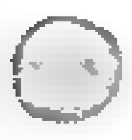

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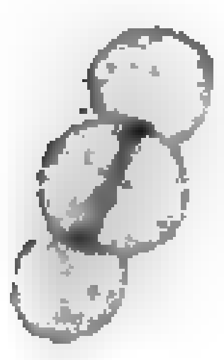

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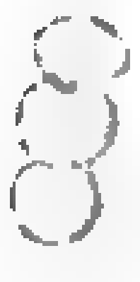

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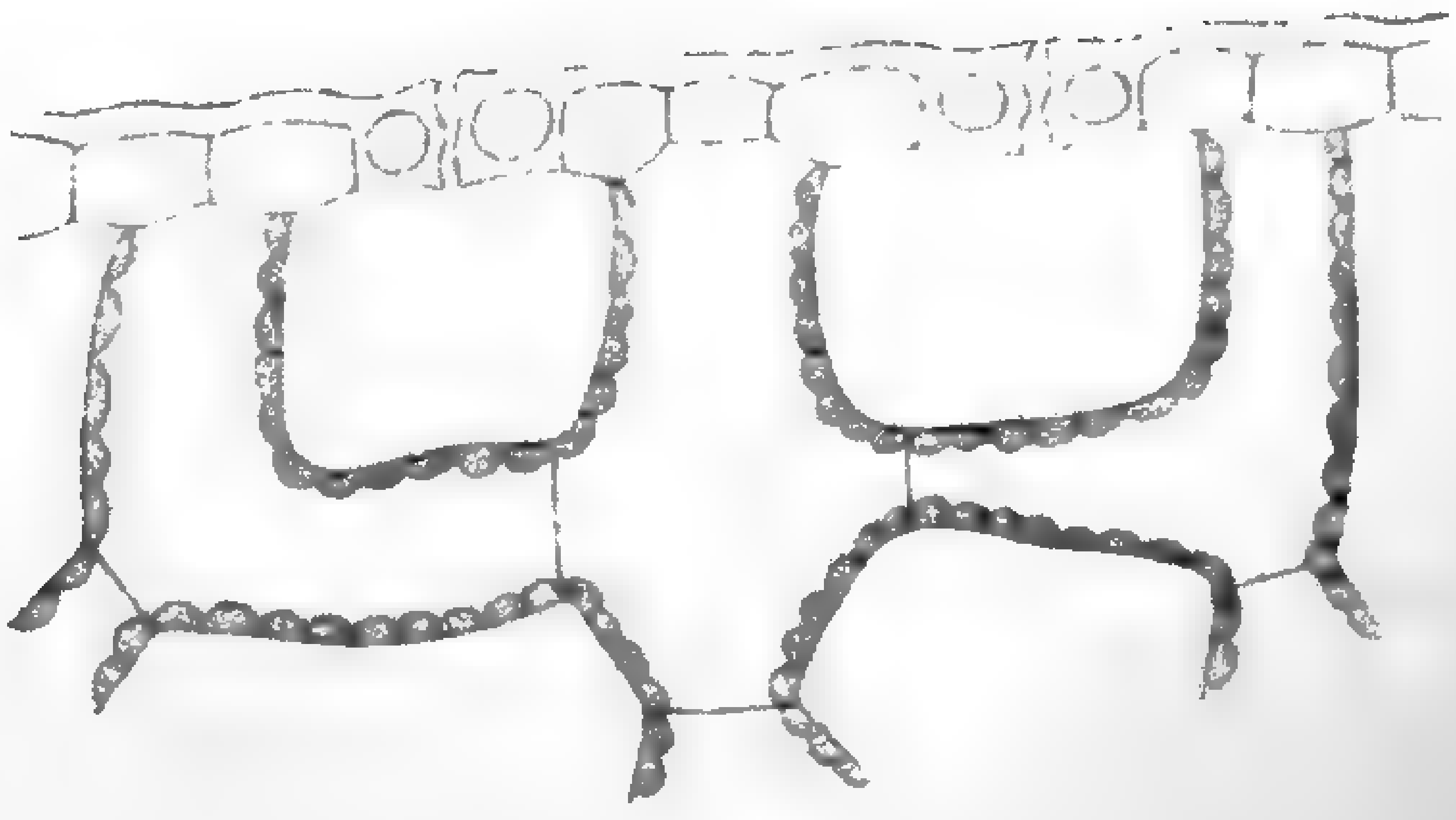

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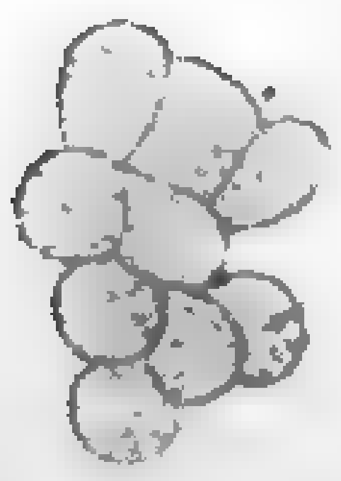

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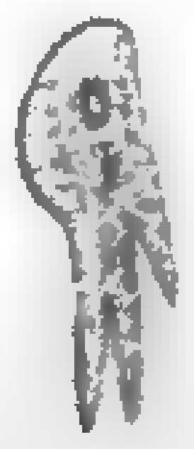

F. Carter sc.

Mintern imp.

UPON PROTOPLASM.

1
cl
A
s
a
2
cl
A
a
3
cl
p
5
cl
P
a
R
s
4
cl
a
6
7
Pc
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9
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cl
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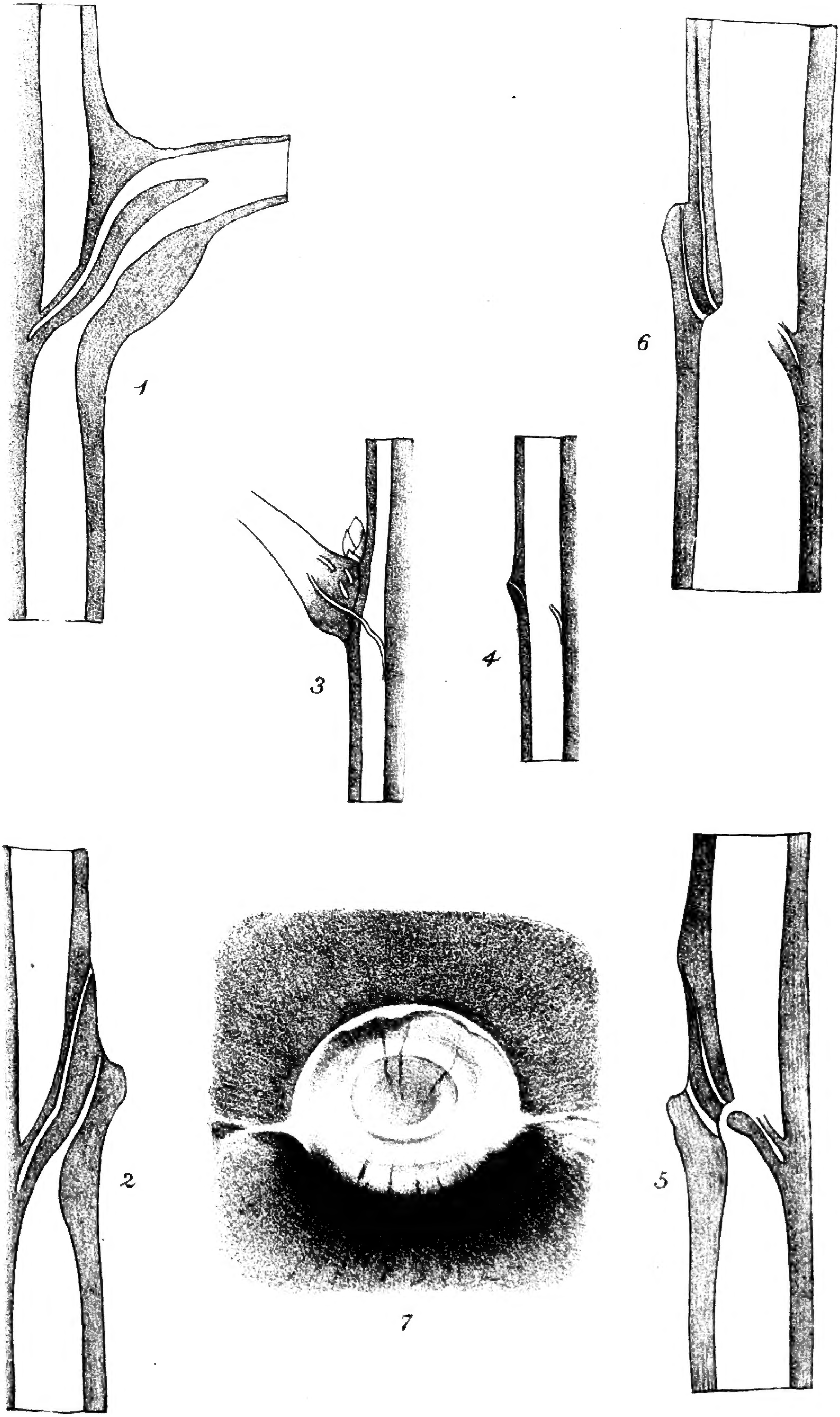
gl
s
8
11
P
12
gl
s
P
13
14

H. N. Ridley, del.
Berjeau & Highley, lith.
West, Newman & C^o. imp.

SELF FERTILISATION OF ORCHIDS.



S.G. Shattock del.

J.N. Fitch lith.

STEM OF DAMMARA ROBUSTA.

1
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14
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17
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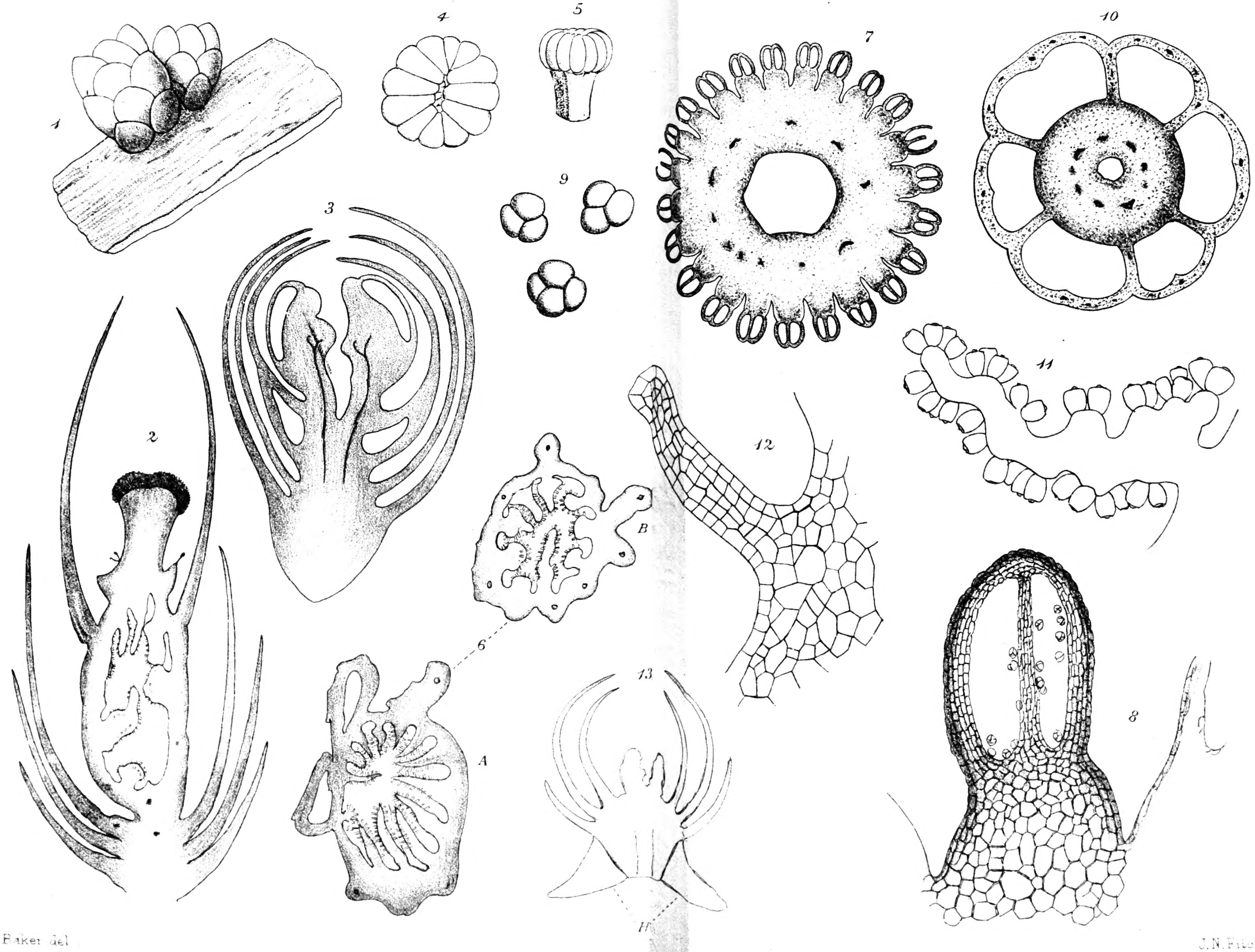
22

E.A.L. Batters del.

J.N. Fitch lith.

NEW MARINE ALGÆ


1
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9
10
11
12
13
A
B
H

E.G.Baker del.

J.N.Fitch lith.

STRUCTURE OF CYTINUS BARONI.